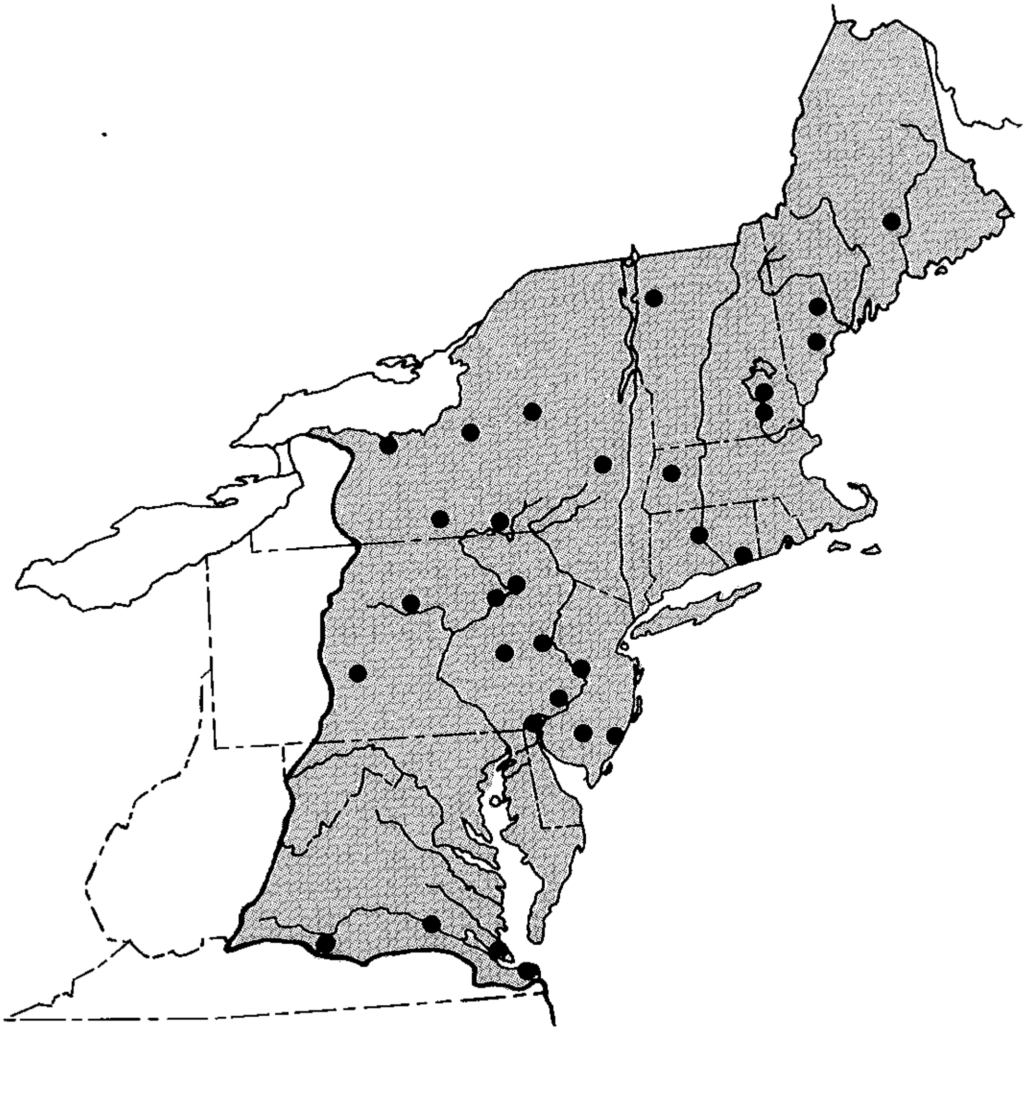
NORTHEASTERN UNITED STATES WATER SUPPLY STUDY

# PRELIMINARY STUDY OF LONG-RANGE WATER SUPPLY PROBLEMS OF SELECTED URBAN METROPOLITAN AREAS

## VOLUME II AREA REPORTS



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J. L. Agnozzi
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of

# SELECTED URBAN METROPOLITAN AREAS

## VOLUME II

## AREA REPORTS

Prepared for

North Atlantic Division
U.S. Army Corps of Engineers

by

Anderson-Nichols & Company, Inc.
Boston-Concord-Vernon-Horsham

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The Preliminary Study of Long-Range Water Supply Problems of Selected Urban Metropolitan Areas was conducted by Anderson-Nichols and Company, Inc., Boston, Massachusetts, under contract to the North Atlantic Division, U.S. Army Corps of Engineers as part of the Northeastern United States Water Supply Study. The Study Report is presented in two parts - Volume I, Main Report, and Volume II, Area Reports.

The Main Report summarizes and outlines the methodologies used, and presents the general findings for 26 urban metropolitan areas. The Area Reports includes a chapter for each urban metropolitan area containing detailed population, water supply data, projections to the year 2020, supply deficits, and regional opportunities for solutions to problems.

The Anderson-Nichols effort was conducted under the general direction of Jerome Degen, Senior Vice President, and Warren A. Guinan was Project Coordinator. Project Engineers included Richard C. Boynton, Anthony S. Donigian, Jr., Joseph G. Hugo, Stephen D. Parker, and Frederick H. Sharrocks, Jr.; and Charles W. Amos, Edward A. Rainen, Ron Etzion, and Stanley J. Portman were Engineering Assistants.

# PREFACE

In the densely populated northeastern United States, where four of every five people live in urbanized areas, water is carried to its users by numerous complex systems, involving dams, reservoirs, aqueducts, pumping plants, water treatment plants, and intricate pipeline networks. Despite these seemingly adequate systems, the five-year drought of the 1960's created an emergency situation: extra pipelines were pressed into service, some areas were actually supplied with drinking water by tank trucks, and about 14 million people, or 28 percent of the Northeast's population, were subjected to restrictions on water use.

While that drought is now history, it demonstrated clearly that many water supply systems in the Northeast were barely adequate to meet demands, even under severe restrictions and emergency operations.

Since the drought, some communities have made substantial progress in expanding their water supply capabilities. However, many others have not been able to expand because of policitical, economic, or environmental reasons. A recurrence of a drought similar to that of the 1960's in these areas would have much more severe implications, because increases in population and technological advances bring about greater demands for water. It is projected that the population of the Northeast will increase by 70 percent, from 50 million to 85 million people, by the year 2020, with corresponding increases in industrial and commercial activity. Water presently required per person, excluding that used to manufacture goods and provide necessary services, is approximately 128 gallons per day. Projections for 2020 increase the total to 153 gallons.

It is clear that the people of the vital northeastern United States need more water - not primarily to provide for the present - but to keep abreast of ever-growing future demands. Planning must transcend the historical concept that water supply is a local problem confronting only local resources and talents.

Presently available water supply facilities will not support projected demands. Water supply planners must consider integrating their plans for development, they must also combine and relate water supply development to other urban needs, such as transportation, communications and power. Though these categories by no means cover everything necessary for urban living, it is easy to see that a shortage of any of them would severely curtail or stop normal development. Competition for water exists among the varied interests created by modern society. Changes in the industrial economy have provided individuals with increased income and leisure time, but such an economy concomitantly expects a need for more water.

Planners at every level are recognizing the need to provide efficient utilization of water resources. In 1965, the 89th Congress recognized the growing importance of coordinated regional planning to meet the future water supply needs of the Northeast, and authorized the formation of the Northeastern United States Water Supply (NEWS) Study, under Title I of Public Law 89-298. The NEWS Study is being conducted by the North Atlantic Division of the U.S. Army Corps of Engineers in cooperation with other concerned Federal, State, regional and local government agencies and with the water supply industry. The study will analyze current and long-range needs, with emphasis on urgent problems, and produce coordinated general plans for water supply development and management.

The objectives of the NEWS Study are·

1. To establish guidelines for Federal participation in water supply development.

2. To develop coordinated, regional plans for the efficient construction, operation and maintenance of water supply developments in the Northeast.

3. To recommend "action" programs for Federal, State, regional and local agencies, and for public organizations.

4. To select programs and geographic areas which may require continued planning at the Federal level.

The Preliminary Study of Long-Range Water Supply Problems of Selected Urban Metropolitan Areas is a major element of the NEWS Study. It analyzes the long-range municipal, industrial and domestic water supply requirements of 26 selected urban metropolitan areas throughout the Northeast. The 26 areas may experience major regional problems in assuring water supplies during the study period, the present through the year 2020.

Two general planning assumptions evolved to guide the development of this report and to assure that its findings are valid. They are:

- that water provided for domestic and industrial supply will have a very high (if not the highest) priority among all uses of water throughout the planning period; and

- that use of water for this purpose need have no permanently adverse effect on the environment.

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# CHAPTER 1. INTRODUCTION

The Preliminary Study of Long-Range Water Supply problems of Selected Urban Metropolitan Areas (UMA Study) is an evaluation of the water supply situations of 26 urban metropolitan areas located throughout the Northeastern United States Water Supply Study Area.

The 26 UMA's were selected on the basis of population and derived from 28 Standard Metropolitan Statistical Areas defined by the U.S. Office of Budget and Management and four urban areas which are projected to qualify as SMSA's by the year 2020. Figure 1 shows the locations of the 26 UMA's.

The three general objectives of the UMA Study are

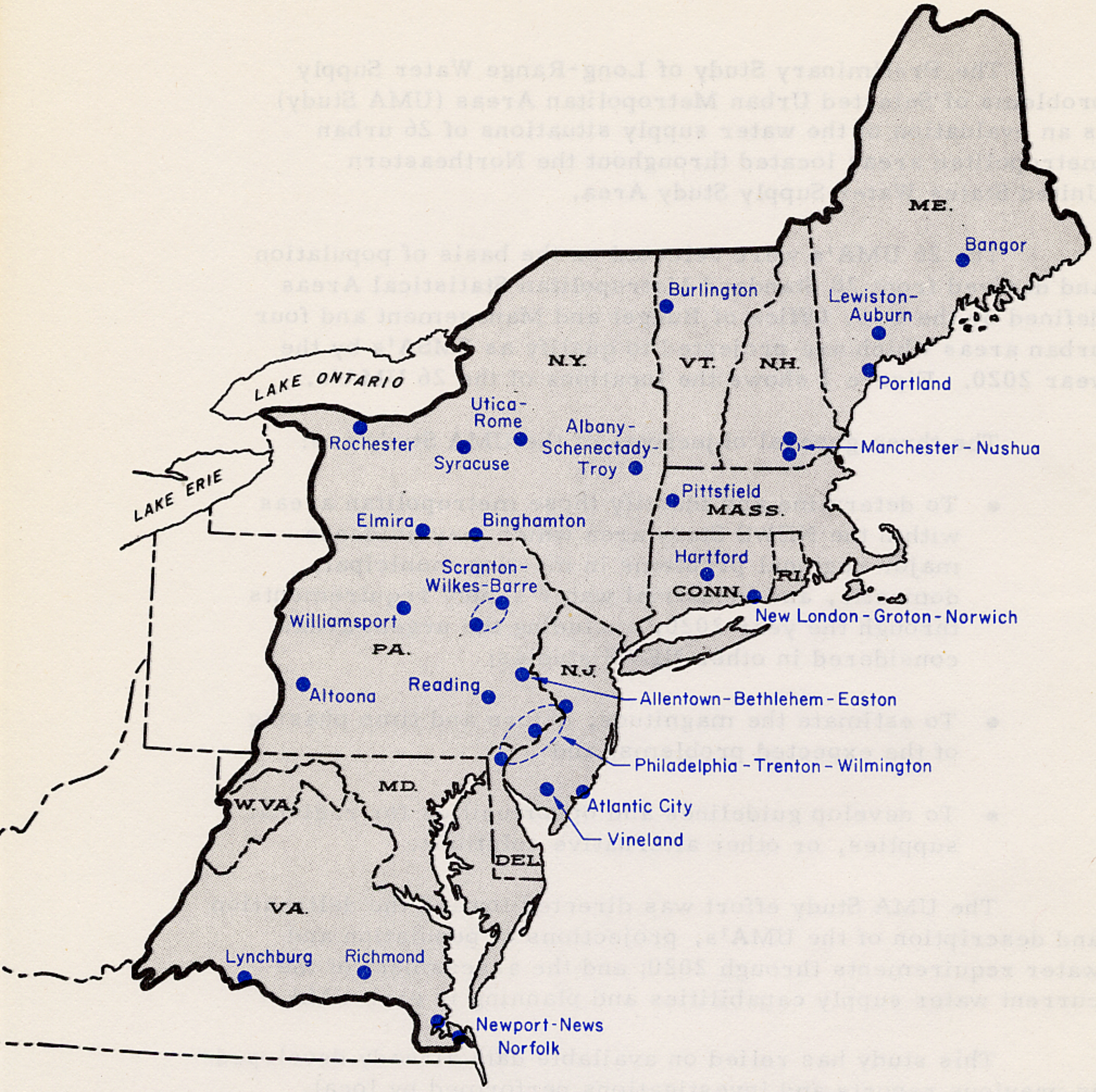
- To determine and identify those metropolitan areas within the NEWS Study area which may evidence major regional problems in meeting municipal, domestic, and industrial water supply requirements through the year 2020, excluding the urgent areas considered in other NEWS studies;

- To estimate the magnitude, nature and time phasing of the expected problems; and

- To develop guidelines and opportunities for regional supplies, or other alternative solutions.

The UMA Study effort was directed toward the delineation and description of the UMA's, projections of population and water requirements through 2020; and the assessment of the current water supply capabilities and planning in each UMA.

This study has relied on available data already developed in previous reports and investigations performed by local, regional, state or federal agencies, with new data being generated only where data were unavailable. Its scope is insufficient to define projects, and it serves only as a tool to assist in the decision process relative to urgency and magnitude of water supply development. The Corps of Engineers does not advocate at this time, in whole or in part, any alternative solution set forth in this study, because it is subject to review and appropriate




**URBAN METROPOLITAN AREAS**

**FIGURE 1**

revision. Neither does the study presume that the alternatives listed for each UMA are complete; at best they are representative.

In recent years, regional, State and local agencies throughout the Northeast have attempted to project their water supply requirements over a similar 50-year period. When compared with this study's population and water demand forecasts, some differences may be apparent. The variances can be attributed to the different methodologies and base year used for the purpose of the projections and some dissimilarities in the sizes of the areas under consideration.

Recognizing these possible incompatibilities between existing reports and this study, the existing plans and studies for each area were reviewed and evaluated with respect to meeting the needs of the area through the year 2020. Each area was scrutinized for factors favoring economic efficiencies, either through nonstructural measures such as collective planning, design, and management of water supply, or structural projects including physical interconnection of proximal systems, or combinations of these.

When and where water deficits are likely to occur, alternative courses of water supply development have been proposed. This study recognizes possible difficulties in implementing some of the alternative courses because of existing constraints, and as such may not have been included in the plans of local agencies. However, the proposed alternatives in this study are in the best interest of solving future water supply inadequacies regardless of such constraints which in many cases were created by man and could be dissolved.

The UMA Study Report presents regionalization opportunities and other alternatives for the solution of the water supply problems. It is presented in two parts -- Volume I, Main Report, and Volume II, Area Reports. Volume I includes a full description of the UMA, study and the methodologies used during its conduct, an explanation of the derivation of each of the UMA's and their population, water demands and water deficits situation, a narrative on the concept of regionalized water supplies and the study's general findings and conclusions. Volume II includes detailed descriptions of each of the UMA's analyses of their water supply problems, and detailed preliminary alternative solutions to these problems.

No attempt has been made to advocate regionalization as the only solution to water supply problems in a UMA. A regional approach, however, seems preferable to piecemeal developments that result in a proliferation of utilities, often wasting resources without actually solving the problem.

In the total Northeastern United States Water Supply Study Program, the UMA Study is categorized as a preliminary level study. The two other levels are engineering feasibility, and survey scope or authorization study. Based on a thorough evaluation of all the data and analyses included in the two volumes of this preliminary report, the NEWS Study planners will determine the need for feasibility-level study of any of the urban metropolitan areas.

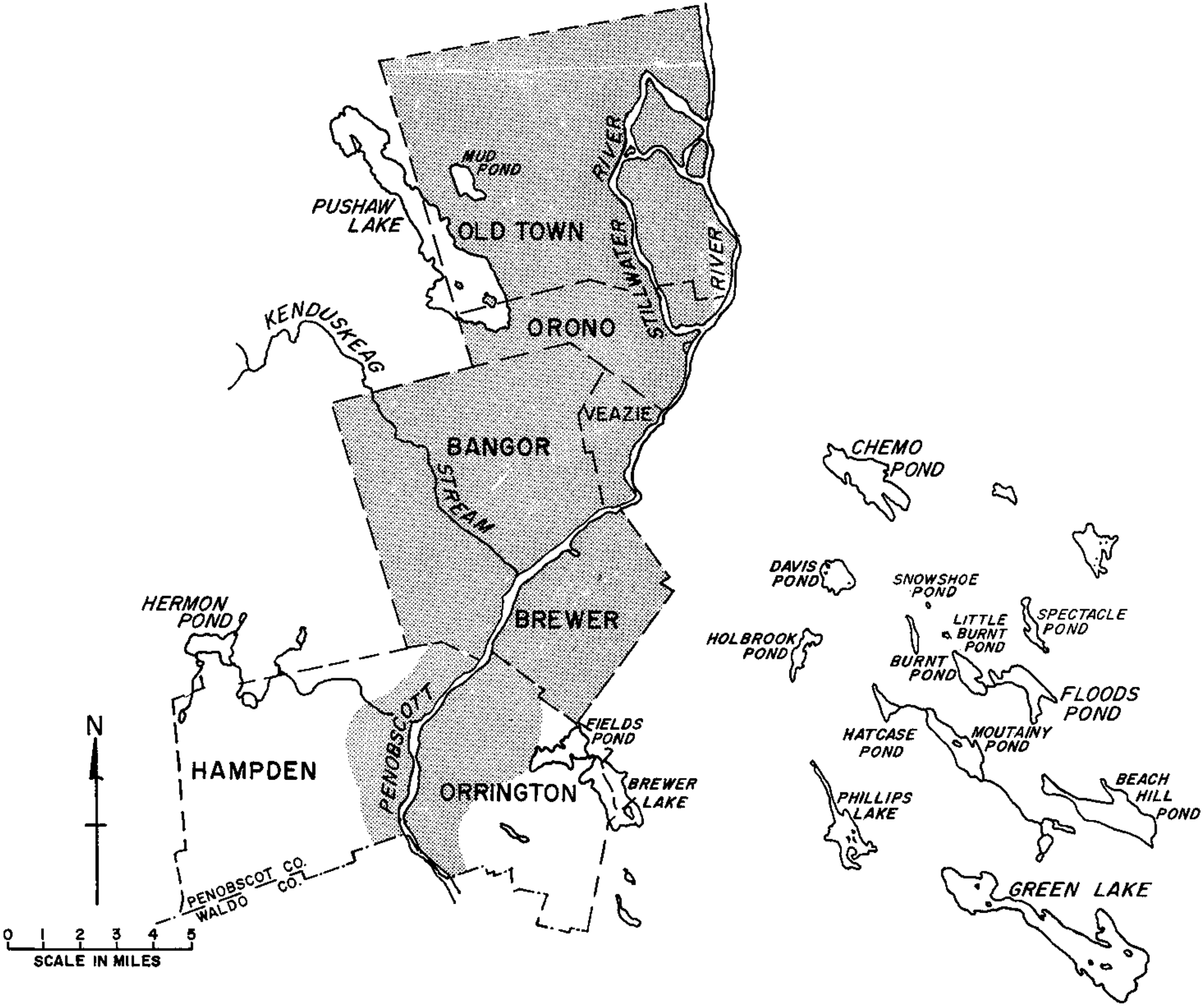
# CHAPTER 2. BANGOR

The Bangor UMA is situated approximately 130 miles northeast of Portland, Maine, in the southern portion of Penobscot County. Located on the Penobscot River, approximately 25 miles upstream from Penobscot Bay and nearly 50 miles inland from the Atlantic Ocean, the UMA consists of the core city of Bangor, the city of Brewer, and all or portions of the towns of Old Town, Orono, Veazie, Hampden, and Orrington. The UMA expected to evolve by the year 2020, with its total land area of nearly 130 square miles, is illustrated on Figure 2 .

Since the UMA is a part of the Penobscot River Valley, its topography is relatively flat, though sporadic hills, reaching altitudes 200 to 300 feet above sea level, dot the landscape of northwestern Bangor and northeastern Orono. The central topographic feature in the UMA is the Penobscot River, which flows from the northeastern border to the south-central portion, passing through highly developed sections of Bangor and Brewer. The drainage area of the Penobscot River at Bangor is approximately 7,000 square miles. Within the UMA, major tributaries to the Penobscot River include the Stillwater River and the Kenduskeag Stream. Pushaw Lake is another significant water body located within the UMA boundaries.

Climate in the Bangor area is classified as continental, with day-to-day weather changes characteristic of New England. From June through August, the summer mean temperature average is 65.5°F. Winter temperatures, based upon the months of December, January, and February, average 20.7°F. The record extremes are 96°F and -30°F. Precipitation generally averages 43 inches annually, of which 20 inches are recorded as runoff. The average snowfall is about 97 inches.

Interstate Route 95 connects the Bangor UMA with the heavily populated northeastern seaboard to the south. Highway distances, driving south, are about 135 miles to Portland, Maine, and about 240 miles to Boston, Massachusetts. Rail freight service is provided by the Maine Central Railroad and passenger services are available at Bangor International Airport.




BANGOR UMA

FIGURE 2

Bangor is the principal trading and commercial center of northeastern Maine. Originally a port city, it was the center of America's lumber industry in the 1870's, and is now a manufacturing center. During the 1960's, the city of Bangor suffered a major economic set-back with the phasing out of Dow Air Force Base (Dow AFB).

Compared to other population centers of the North Atlantic Region, the Bangor area has a higher employment concentration in the areas of forestry and fishing. The most significant manufacturing industries are paper and allied products, followed closely by lumber and wood products. Food and textile products are also important, although the fastest growing manufacturing industries have been chemicals, non-electrical machinery, printing, shoes and apparel.

As a whole, the area is not expected to experience extremely rapid growth, either in per capita income or employment. Employment is, however, expected to increase in all water-using industries except primary metals. Paper, food, and textiles are projected to gain prominence in relation to the average importance of these industries throughout the entire North Atlantic Region.

## POPULATION

During the 1960's, the total population of the UMA decreased by approximately 4 percent. The city of Bangor, however, declined 15 percent, because of the loss of military and related personnel at the closing of Dow AFB.

Population projections indicate that the UMA will grow at a somewhat slower rate than it has in the past, notwithstanding the effect of Dow Air Force Base. The 2020 population is expected to be more than 46 percent greater than that of 1970.

Approximately 90 percent of the population of the towns of Hampden and Orrington which had inhabited the portions of the town included in the UMA, are expected to continue to do so in the future.

Data for populations and resultant densities for the entire UMA in the various benchmark years are given in Table 1.

TABLE 1

POPULATION DATA

BANGOR UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in Thousands) | 72.6 | 69.7 | 74.6 | 87.3 | 102.0 |
| Population per square mile | 560 | 535 | 575 | 670 | 785 |

## WATER USAGE

Water use projections were determined for the benchmark years 1980, 2000, and 2020. Available data for the mid 1960's indicate that the five existing utilities - Bangor Water District, Old Town Water District, Penobscot County Water Company, Brewer Water District, Hampden Water District - served an average of 7.2 mgd to approximately 66,000 persons, or 94 percent of the UMA's population. About 7 percent of the water output by these utilities was supplied to industrial users.

Total industrial usage for water in the mid 1960's UMA was estimated to be 19.2 mgd, and this demand is expected nearly to double by the year 2020. Because of the availability of suitable and sufficient water to serve the need of private industry in the area, the percentage of industrial water supply to total supply should remain essentially constant; i.e., most additional industrial water demands are expected to be satisfied from private sources.

M & I water usage data appear on Table 2. Figure 3 shows projected trends for both population and M & I water use.

TABLE 2

WATER USAGE

BANGOR UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 6.7 | 8.6 | 11.6 | 15.9 |
| Publicly-supplied industrial | 0.5 | 0.6 | 0.8 | 1.0 |
| TOTAL M & I | 7.2 | 9.2 | 12.4 | 16.9 |
| Publicly-supplied industrial | 0.5 | 0.6 | 0.8 | 1.0 |
| Self-supplied industrial | 18.7 | 22.1 | 27.9 | 36.5 |
| TOTAL INDUSTRIAL | 19.2 | 22.7 | 28.7 | 37.5 |
| Water Use (gcd) (Based on M & I) | 108.1 | 123.3 | 142.0 | 165.7 |

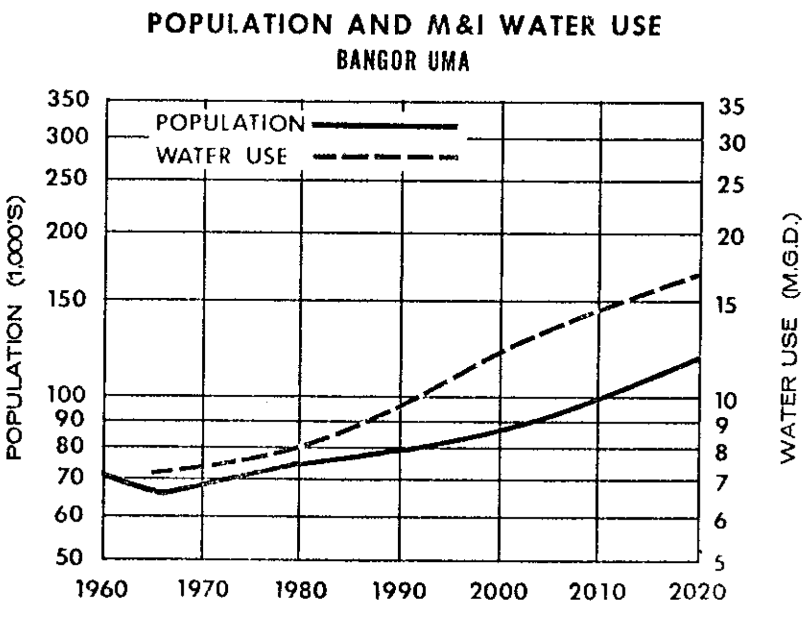



FIGURE 3

## KNOWN WATER SUPPLIES

### Summary

The Bangor Water District was created by the Maine State Legislature, and approved by the voters in the spring of 1957. It has the function of "supplying service to Bangor and other cities, towns, corporations or districts and the inhabitants thereof, who wish to purchase water from the District. The Act creating Bangor Water District specifically authorized the acquisition and utilization of Floods Pond, Burnt Pond, Little Burnt Pond, Spectacle Pond, Beech Hill Pond, Mountainy Pond, and Snowshoe Pond, in any combination needed to provide an adequate water supply. Floods Pond, Burnt Pond and Little Burnt Pond are being used at present.

Floods Pond, Burnt Pond, and Little Burnt Pond, situated approximately 15 miles east of Bangor, collectively share 8.34 square miles of drainage area and have a 7.0 mgd safe yield. Water from these three sources combines naturally in Floods Pond. Water quality is uniformly excellent - clear, soft, and cold - requiring minimal treatment (chlorination, fluoridation, and control of its alkalinity). A transmission line, extending from Floods Pond to Bangor, measures about 14.5 miles. Appurtenances now in place will permit service to Brewer, the Veazie-Orono system, and Old Town at some future date.

The average 1965 output of the Bangor Water District was 4.20 mgd, or about 60 percent of maximum system capacity. In 1970, average daily output dropped about 4 percent, thus reflecting the phase-out of Dow AFB.

The Brewer Water District serves Brewer exclusively, obtaining a safe yield of about 2.0 mgd from Hatcase Pond. The 1965 output of the system was about 0.71 mgd; this increased to about 0.83 mgd in 1970. Representatives of the Brewer Water District believe that their system will be adequate for 8 to 10 years. When additional water is required, they anticipate connecting to the Bangor System.

The Penobscot County Water Company, a privately owned system, supplies water to Orono and Veazie. Chemo Pond was the original supply source, but because of seasonal changes in color it was discontinued as the primary source in 1961. The system now obtains about ninety-five percent of its supply from two gravel-packed wells, and emergency water from Chemo

Pond. In 1965 the system output was approximately 1.32 mgd, although the total capacity of the system is 4.32 mgd - 1.44 mgd from the wells and 2.88 mgd from Chemo Pond. In recent years, the system has been experiencing problems with the quality of its treated ground water supply, and the Penobscot County Water Company is currently negotiating with Bangor to obtain water from that system.

The Old Town Water District utilizes three wells, with an estimated combined safe yield of 2.0 mgd. The District supplies about 35 percent of its output to other communities which were not included in the UMA because of their very small size and remote locations. The total water use in 1965 in Old Town itself was only about 0.5 mgd.

The Hampden Water District obtains its relatively small supply from ground water. However, present levels of iron and manganese in the ground water of the UMA may increase to concentrations that would require treatment or abandonment of this source.

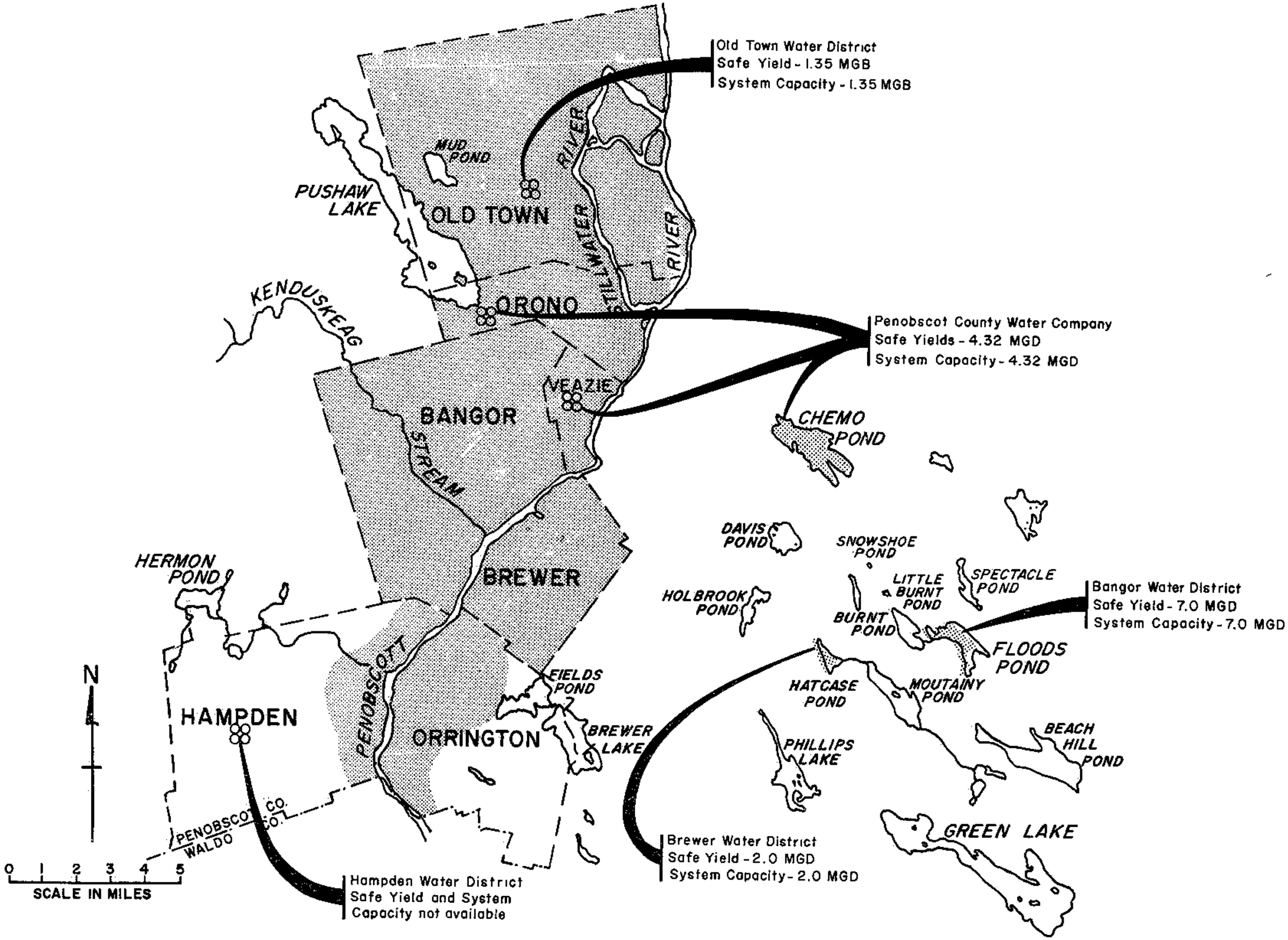
Brewer is now the only community other than Bangor to have a surface-water source as its supply. Brewer, however, has indicated that it plans no further development and expects to purchase water from Bangor when necessary. Thus, the Legislative mandate to the Bangor Water District makes it necessary for the District to stay ahead of the demand in the UMA. Table 3 lists pertinent data for the existing water supply systems. The situation is represented graphically on Figure 4.

TABLE 3

KNOWN WATER SUPPLIES

BANGOR UMA

| System | Mid 1960's Pop Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Bangor Water District | 36,040 | 4.31 | Surface | Floods Pond | 7 0 | N/A | 18.0 | 7 0 |
| Brewer Water District | 9,154 | 0.71 | Surface | Hatcase Pond | 2 0 | N/A | 2.0 | 2.0 |
| Penobscot County Water Company | 10,408 | 1 32 | Ground Water<br>Surface | Wells<br>Chemo Pond | 1 44<br>2.88 | N/A<br>N/A | N/A<br>N/A | 4.3 |
| Old Town Water District | 7,162 | 0.62 | Ground Water | Wells | 1 35 | N/A | N/A | 1.35 |
| Hampden Water District | 3,830 | 0 26 | Ground Water | Wells | N/A | N/A | N/A | N/A |




**KNOWN WATER SUPPLIES**
**BANGOR UMA**
**FIGURE 4**

Future Adequacy

Table 4 compares the capability of existing systems with the projected water demands for the various benchmark years. The capability in the mid 1960's include only the aggregate capacity of the Bangor, Brewer, and Old Town systems, plus the ground water capability of the Penobscot County system. It is these facilities that would serve as a basis for a regional system. The comparision in the table reveals that at least 5.1 mgd should be developed shortly before the year 2000. However, a ground water quality deterioration, common throughout the area, may dictate the development of as much as 8.0 mgd.

TABLE 4

**ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS**
BANGOR UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| M & I Demand | 7.2 | 9.2 | 12.4 | 16.9 |
| Present Capacity | 11.8 | 11.8 | 11.8 | 11.8 |
| Deficit | -- | -- | 0.6 | 5.1 |

## DESIRABILITY FOR REGIONALIZATION

The Act creating the Bangor Water District should ultimately result in a regional water supply system serving the entire UMA. The existing water systems will continue to operate as long as practicable, but if a system should prove inadequate or undependable, the future supply for that community will be assured because of evolving regionalization.

The Bangor Water District, regional in concept, planning, and action, already supplies water to portions of Hampden and Eddington. Additionally, Brewer, Orono and Veazie will probably obtain their water from the Bangor Water District within the time frame of this study. Construction is already underway to connect Orono-Veazie to the District.

Because of the apparent deterioration of ground-water quality in the area, those communities now relying on wells for supply may, within the time frame of this study, be forced to seek other sources. Joining the Bangor Water District, in all probability, should ultimately prove to be more economical than developing new sources. Yet it may also prove economical to have the present systems continue to operate as long as possible.

## DEVELOPMENT ALTERNATIVES

In order to insure the availability of enough high quality water, it has been assumed that all future demands above the existing system capability will be met exclusively by the Bangor Water District. In fact, other local utilities may be able to develop additional wells to meet their individual requirements, even though the cited deficits are based on the entire UMA, and localized shortages can occur.

In 1967, a report prepared by consultants for the City of Bangor indicated that the safe yield of Floods Pond can be increased by 7 mgd by pumping water from Spectacle Pond and from Beech Hill Pond. Those now associated with the Bangor Water District believe that this amount may be slightly high; an expected increase of 5 mgd can be considered as reasonable. The discrepancy is probably the result of the recreational nature of these ponds, and the difficulty in determining the effects of the drawdown resulting from the pumping. Thus the safe yield of Floods Pond with such augmentation is between 13 and 15 mgd.

If this project should not meet the quantity requirements, other lakes with high quality water could be pumped into Floods Pond. The costs involved would naturally be higher, because of the extra pipes and pumping required. In either case, the 12 mgd pumping capacity at Floods Pond would have to be expanded; considerable savings would still be realized.

Floods Pond has the unique distinction of being the only remaining pond in which the Sunapee trout, already marked as an endangered species, exists in genetically pure form in a native habitat. A strong possibility has been indicated that action may be taken to secure Federal protection of Sunapee trout, to have the Maine State Legislature act to prohibit pumping of water from other ponds into Floods Pond, or to secure stringent safeguards to decontaminate transferred water so that unwanted species remain excluded from the pond. Such precautions would include fine-mesh screening and chlorination. Environmental aspects of this situation should be carefully evaluated before any water pumping is effected.

Until 1957, the Penobscot River was used for water supply by the city of Bangor, but because of increased pollution, use of the river was abandoned. The advantages of using this source are obvious, and if advanced treatment procedures, along with increased government control of effluents, improve the quality of the water, the river could be utilized once again. With a mean flow of about 8000 mgd, and a low flow of about 1300 mgd, the river is virtually an unlimited source of water for the UMA.

## CONCLUSIONS

An additional capacity of at least 5.1 mgd, and possibly as much as 8 mgd, will have to be developed by 2020. The latter requirement would result if the facilities of the Penobscot County Water Company were abandoned. Firm plans of the Bangor Water District will increase present capacity by at least 5 mgd. This would preclude the projected deficit of 5.1 mgd, but not of 8 mgd.

Regionalization seems to be evolving from actions of the State Legislature, and deterioration of ground water quality in the UMA. The Bangor Water District is the central system in the trend, to a regional supply.

Opportunities are available to increase Bangor Water District capacity above present firm plans. Full utilization of its existing facilities which develop Floods Pond, the present source, can be realized from nearby natural surface water sources. However, environmental consideration of the Sunapee trout, marked as an endangered species, is required. Planning reflects that no major water deficit should materialize. The Bangor Water District, the largest water utility in the UMA, is proceeding on the basis that it can and will supply water to its neighbors, because of its legislated responsibility and authority; therefore, it becomes the logical choice as a base for expansion to a full regional water supply system, as the need arises.

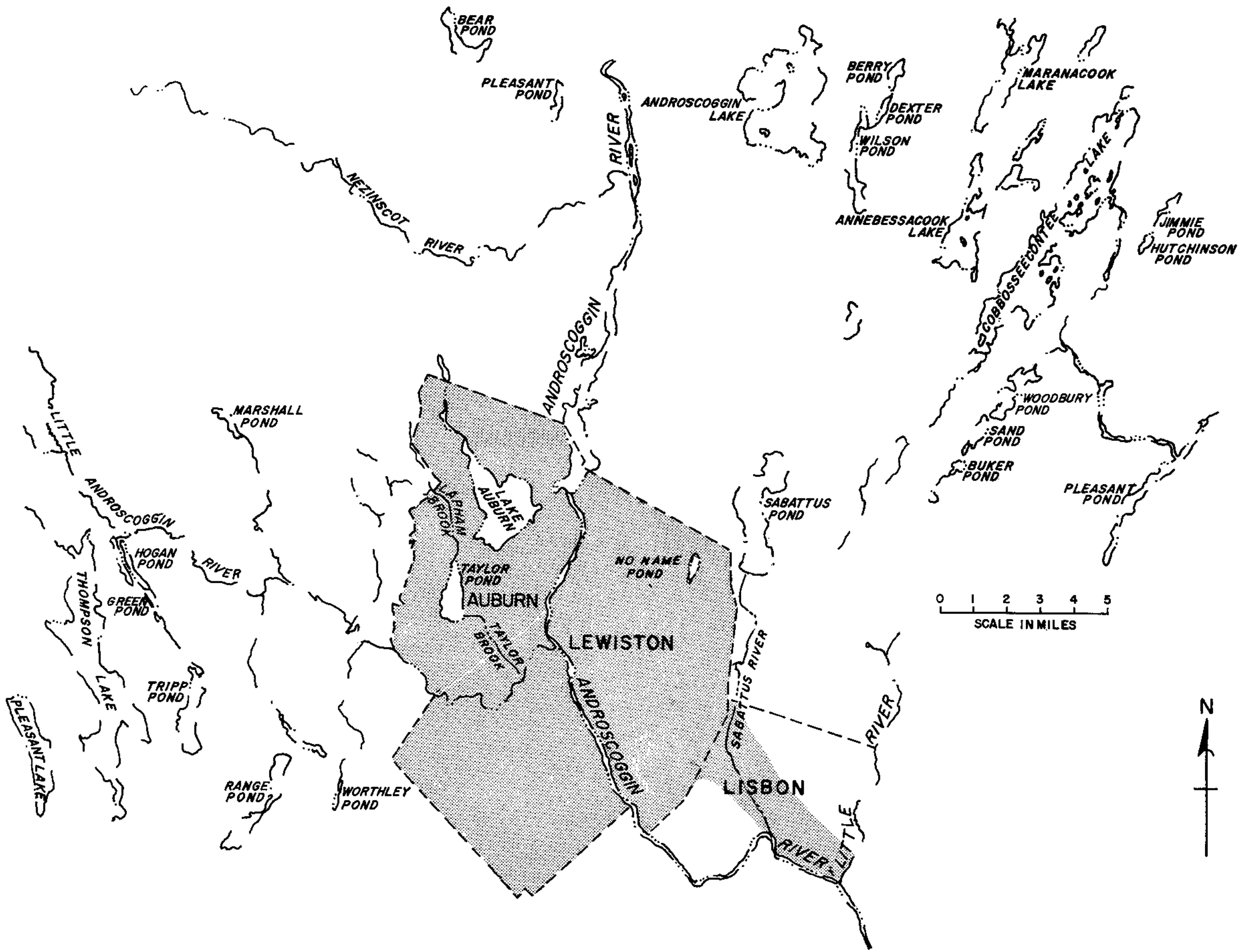
# CHAPTER 3. LEWISTON-AUBURN

The Lewiston-Auburn Urban Metropolitan Area, illustrated on Figure 5, is located in southeastern Androscoggin County, Maine. The UMA expected to evolve by the year 2020 will encompass the cities of Auburn and Lewiston, and a densely populated strip along Maine Route 196 in the town of Lisbon, as far as Lisbon Falls. Total land area of the UMA approximates 103 square miles.

The UMA lies in the New England Physiographic Province and is characterized by subdued rolling hills with numerous streams and rivers flowing at low gradients. Separating the cities of Auburn and Lewiston is the Androscoggin River, which flows from the north-central portion of the UMA to the southeastern corner, and marks the southern boundary of Lisbon. Elevations along the banks of the river, the main topographic feature of the area, are approximately 200 feet above sea level. The topography of the urbanized areas of Auburn and Lewiston is generally flat; there are some hills, however, reaching heights of 200 to 300 feet, and occasionally 400 feet.

Rural fringe areas of the UMA are wooded, and subdivided by numerous brooks and ridges. Elevations in these areas range from 300 to 400 feet above sea level, with a few hills slightly higher than 500 feet. Among the important lakes, ponds, and brooks are Lake Auburn, No Name Pond, Taylor Pond, Taylor Brook, Sabattus River, Little River, and Lapham Brook.

The climate of the Lewiston-Auburn UMA is typically continental. Mean temperature is about 45°F, with monthly extremes ranging from about 19°F in January to 69°F in July. Precipitation, more or less evenly distributed throughout the year, averages 42 inches, of which approximately 20 inches is measured as runoff. Winter is relatively severe: for the thirty years of record prior to 1961, snowfall averaged 74 inches. As with most of New England, frequent variation in day to day weather conditions is considered normal.




LEWISTON-AUBURN UMA

FIGURE 5

The principal highway is Interstate Route 95, providing the UMA with a link to Portland, Boston, and the New York City area. Rail freight service is provided by the Maine Central Railroad and the Boston and Maine Corporation. Scheduled passenger and freight air transportation is furnished by those airlines serving the Auburn-Lewiston Airport.

Two hydro-electric power plants located near the UMA give the area one of the highest water power potentials in New England. The "Twin Cities" of Lewiston and Auburn constitute an important trade and distribution center.

Lewiston, second largest city in Maine, is a manufacturing center, with principal products including textiles, such as cotton goods, rayons, and woolens, as well as additional products including shoes, belting, sheet metal, medicines, cigars, and beverages.

Auburn is a major shoe manufacturing center, though other products include shoe dyes, paper shoe linings, glass fabrics, rubberized rayon cloth, livestock and poultry feeds, concrete, and brick.

## POPULATION

According to the 1970 Census, population within the UMA increased by approximately 3 percent during the last decade. The city of Lewiston and the town of Lisbon experienced slight population increases, whereas Auburn had a very slight decrease.

Population projections indicate that the UMA will grow at a somewhat lesser rate in the next 50 years than in the past 50 years. The UMA population in 2020 is expected to be 29 percent greater than the 1970 population, but the latter population was 37 percent greater than the 1920 population. UMA population figures and resulting densities for the various benchmark years are listed in Table 5.

TABLE 5

POPULATION DATA

LEWISTON-AUBURN UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 70.3 | 72.5 | 73.8 | 84.7 | 93.3 |
| Population per square mile | 685 | 705 | 720 | 820 | 905 |

## WATER USAGE

Mid 1960's data indicate that three systems served about 91 percent of the UMA's population with an average daily output of 7.6 mgd. These utilities supplied approximately 1.9 mgd to industrial users. It is assumed that all future UMA industrial-water requirements will be supplied exclusively from public sources. Water use projections for the UMA are given in Table 6

Projections indicate that though the 2020 population will increase by only 45 percent over that of the mid 1960's, the water demand will nearly triple. These projected trends are shown graphically on Figure 6.

## KNOWN WATER SUPPLIES

### Summary

There are three publicly owned water utilities which serve the entire UMA· the Auburn Water District, the Lewiston Water Division, and the Lisbon Water Department. Table 7 lists pertinent data for the systems, and they are shown on Figure 7.

The systems serving Lewiston and Auburn are, at present, quasi-regional; though they utilize separate intake structures on Lake Auburn, they do have two interconnecting pipes, remotely situated from the source. The systems are managed independently, but planning by both cities reflects the need for coordination and cooperation in the future.

TABLE 6

WATER USAGE

LEWISTON-AUBURN UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 5.7 | 7.3 | 9.7 | 12.7 |
| Publicly-supplied industrial | 1.9 | 3.3 | 5.8 | 9.6 |
| TOTAL M & I | 7.6 | 10.6 | 15.5 | 22.3 |
| Publicly-supplied industrial | 1.9 | 3.3 | 5.8 | 9.6 |
| Self-supplied industrial | 9.3 | 9.3 | 9.3 | 9.3 |
| TOTAL INDUSTRIAL | 11.2 | 12.6 | 15.1 | 18.9 |
| Water Use (gcd) (Based on M & I) | 117.3 | 143.6 | 183.0 | 239.0 |

POPULATION AND M&I WATER USE
LEWISTON-AUBURN UMA

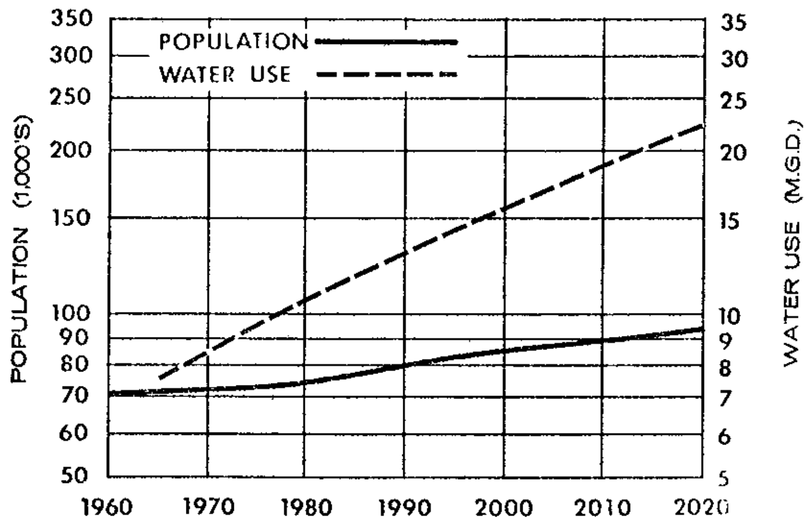
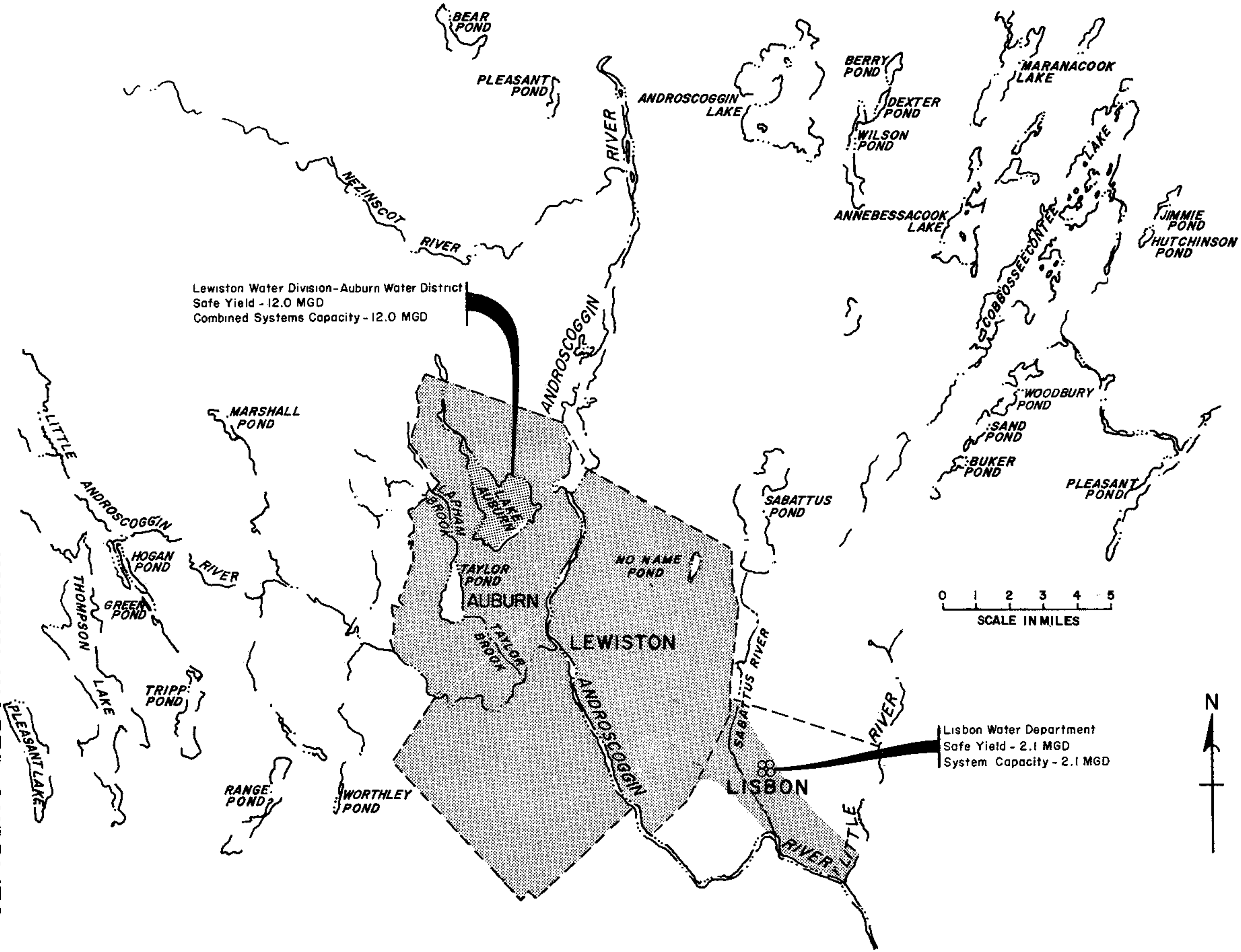



FIGURE 6




KNOWN WATER SUPPLIES
LEWISTON-AUBURN UMA

FIGURE 7

TABLE 7

KNOWN WATER SUPPLIES

LEWISTON-AUBURN UMA

| System | Mid 1960's Pop Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Lewiston Water Division | 37,600 | 5 02 | Surface | Lake Auburn 1/ | 12.0 | chlorination | 12 0 | 12 0 |
| Auburn Water District | 23,000 | 2 00 | | | | | | |
| Lisbon Water Department | 4,850 | 0 52 | Ground | Wells | 2 1 | N/A | N/A | 2 1 |

1/ Auburn Water District shares Lake Auburn with the Lewiston Water Division - with no joint agreement

The present source of water for both Lewiston and Auburn is Lake Auburn, with a safe yield of about 12.0 mgd. The 1965 withdrawal was approximately 7.0 mgd, but increased to 9.0 mgd by 1970, which gives some indication of the increasing use of water in Lewiston and Auburn.

In 1899 the State Legislature authorized the city of Lewiston

> ...to take water from Lake Auburn or any pond in Androscoggin County except Sabattus Pond, sufficient for all municipal, public and domestic purposes in said city...

The authorization aids Lewiston in any search for additional good-quality water. Because of the use of Lake Auburn by both cities, the authorization necessarily includes Auburn.

The Lisbon Water Department obtains its water from four wells with a combined safe yield of approximately 2.1 mgd. The average mid 1960's output of the water department was 0.5 mgd, with about one-half of the total water supplied to industry. Lisbon at this time has no physical or managerial connection with any other system.

## Future Adequacy

The projections in Table 8 indicate that there will be a deficit of 8.2 mgd in 2020.

The present capacity of the three systems will be exceeded sometime between 1990 and 2000. Water availability is the limiting factor; therefore, additional source development will be required to preclude this deficit.

It should be noted that the water deficits reflect the situation for the UMA as a whole, and therefore shortages may possibly develop in one or more of the communities within the UMA before the projected total deficit.

TABLE 8

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

LEWISTON-AUBURN UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 7.6 | 10.6 | 15.5 | 22.3 |
| Present Capability | 14.1 | 14.1 | 14.1 | 14.1 |
| Deficit (mgd) | -- | -- | 1.4 | 8.2 |

## DESIRABILITY FOR REGIONALIZATION

The quasi-regional approach used by Lewiston and Auburn appears satisfactory in meeting their projected water needs. The plans of the town of Lisbon for future development of available ground water obviate the need to develop surface sources in conjunction with Lewiston and Auburn at this time. However, Lisbon must monitor carefully its ground water supply, taking any measures necessary to combat man-made or natural contamination that might result in deterioration of its water quality.

The present water supply situation in the Lewiston-Auburn Urban Metropolitan Area merits consideration of a regional approach. This does not imply abandonment of present water supply systems for a completely interconnected system; the various communities should, however, be aware of the possible advantages of regionalization, if the present water supply situation should change. Economics may some day dictate full regionalization of water supply in the UMA -- single management, interconnection, and joint development of new sources. The existing Androscoggin Valley Regional Planning Commission could be the nucleus for the planning aspect of such regionalization.

## DEVELOPMENT ALTERNATIVES

The present study assumes the satisfaction of future water demands of the UMA only through expansion of the quasi-regional system currently supplying the cities of Lewiston and Auburn. In 1963, the city of Lewiston had a consultant investigate the possibility of augmenting the Lake Auburn supply by the use of Lapham Brook, Thompson Lake, or Androscoggin Lake. A method of increasing the yield of Lake Auburn is generally recognized as a realistic solution to the water supply situation.

Lapham Brook, located approximately one-half mile west of Lake Auburn, is capable of supplying an additional 5 mgd to Lake Auburn, whenever required. The limiting factor controlling the quantity of water available from Lapham Brook is Taylor Pond. Lapham Brook drains into Taylor Pond, which is used heavily for recreational purposes, and any diversion greater than 5.0 mgd would be detrimental to the recreational function. Three diversion schemes were investigated, ranging in cost from $400,000 to $700,000. All schemes are capable of diverting about 5.0 mgd.

The consultant's report also indicates that the next step in obtaining additional water for Lake Auburn after the Lapham Brook diversion would involve either Thompson Lake or Androscoggin Lake. Each of these lakes is capable of supplying approximately 12.0 mgd to Lake Auburn, without adversely affecting water levels.

Chlorination would be the only treatment necessary if the water were allowed to aerate in Lake Auburn under present conditions, but deterioration of water quality due to contamination through pollution would necessitate more extensive treatment. The cost of this as a follow-on project would be about $4 to $5 million for Androscoggin Lake, and approximately $1 million more if Thompson Lake is used. These estimates do not include expenses for obtaining real estate and extinguishing water rights, and in the case of Androscoggin Lake, annual pumping charges.

## CONCLUSIONS

Deficits are projected of 1.4 and 8.2 mgd for the years 2000 and 2020, respectively. Planning reports reflect phased solutions to preclude these deficits; but since the present capacity is adequate for at least 15 years, these plans are considered here only as alternatives.

At this time, regionalization through coordinated planning appears desirable to assure timely action in all parts of the UMA. Mutual cooperation of Lewiston and Auburn, utilizing present facilities, and developing additional supply to augment the raw water of Lake Auburn in two phases also appears desirable. The phasing should provide sufficient capacity to be built economically to meet shorter range future needs, so that taxpayers would not be overburdened unnecessarily. Lisbon's ground water development should be used as long as possible, providing that quality and quantity can be maintained economically.

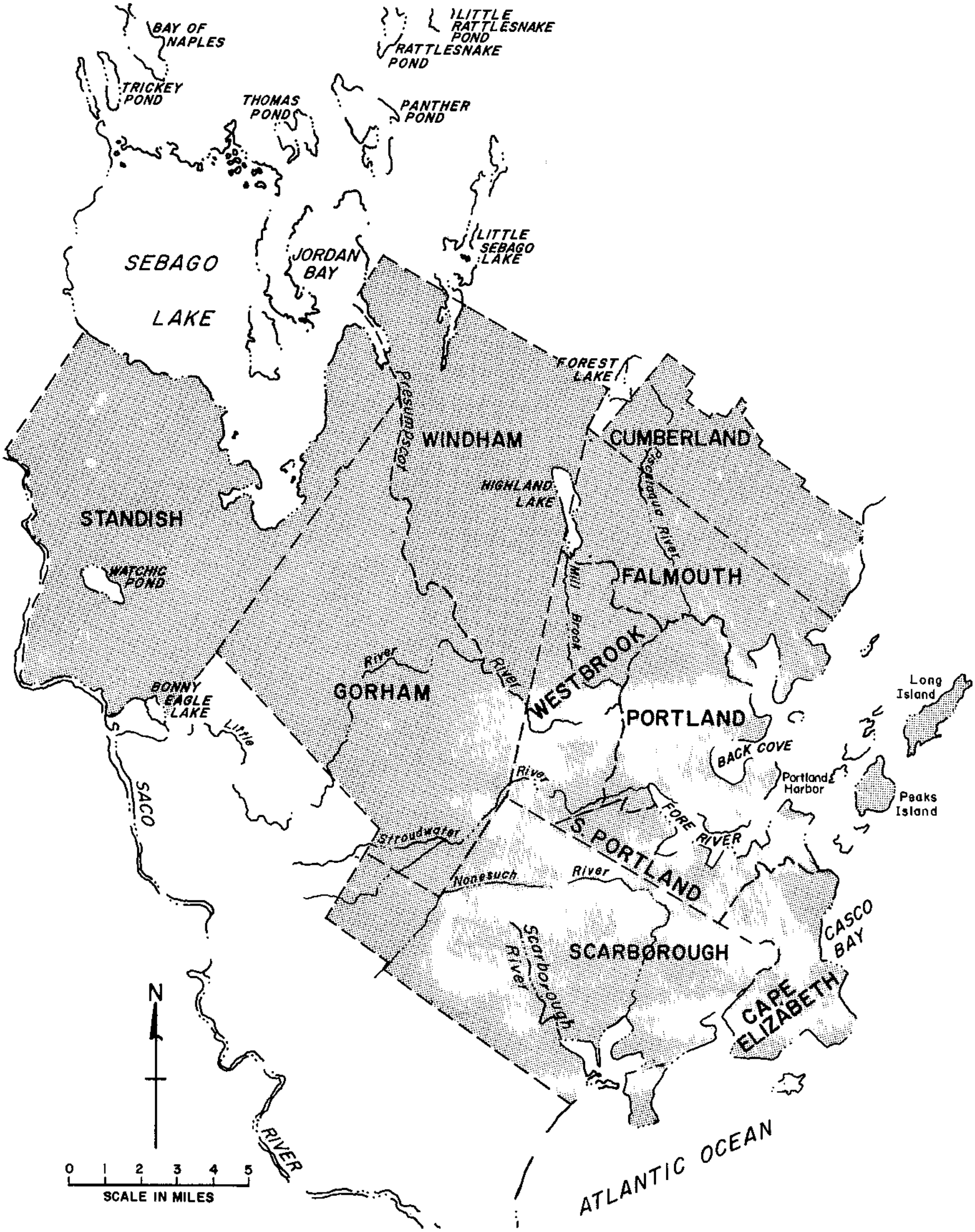
# CHAPTER 4. PORTLAND

The Portland Urban Metropolitan Area, located in the southern coastal portion of Maine, consists of the core city of Portland and the surrounding communities of South Portland, Westbrook, Cape Elizabeth, Cumberland, Falmouth, Gorham, Scarborough, Standish, and Windham, all located in Cumberland County. Figure 6 illustrates the 327-square mile UMA anticipated for the year 2020.

The UMA is characterized by bays, estuaries, peninsulas, and islands; inland terrain is interspersed with lakes and fast-flowing streams. The dominant physical features of the area's topography are Sebago Lake on the western boundary of the UMA, Portland Harbor, and the Presumpscot River. Some lakes and rivers of lesser relative importance are Highland Lake, the Piscataqua River, Stroudwater River, Fore River, Little River, Nonesuch River, and Scarborough River. The topography is generally open, rolling and sloping toward the coast. Elevations vary from sea level at the coastline to 200 feet in the western and northwestern areas. Intermittent hills, mostly in the central and western portions of the UMA, range from 200 to 500 feet in altitude.

Portland's excellent deep-water harbor, with its extensive facilities, is one of the most important ports in New England. It supports high-volume shipping and fishing, and is the manufacturing and commercial center not only for the UMA, but for northern New England. It is a major petroleum port and the eastern terminus of the Portland-Montreal Oil Pipeline. The metropolitan area proper has a diversified manufacturing base. Among the chief products are pulp and paper, textiles, lumber and wood products, furniture, footwear, chemicals, drugs, metal goods and machinery, marble, and stonework. The area is world famous for the canning and freezing of a variety of seafoods. There is also considerable shipbuilding, printing, and publishing.

The employment growth rate of this area has in the past been very low in comparison to the rest of the North Atlantic




**PORTLAND UMA**

**FIGURE 8**



Anderson-Nichols & Co Inc

Region. Although there is still a large employment concentration in such occupations as fishing, forestry, and agriculture, these have experienced a relative decline in recent years. Most rapidly growing industries include electrical machinery, transportation equipment other than motor vehicles, fabricated metals, and apparel. The largest sector of employment is in retail trade and professional services.

Total personal income is expected to grow somewhat faster than population and employment. Thus the relative per capita income of the area should grow, according to Appendix B, NAR Study (Economic Base), although it is still expected to remain below the national average.

Generally, the area has pleasant summers and falls, cold winters with frequent thaws, and springs characterized by unsettled weather. Summers are comfortable, with average temperatures varying from the lower fifties to the upper seventies. Winters are severe; average temperatures vary from the low teens to the mid-thirties. The record extremes are 103°F and -43°F. Heavy seasonal snowfalls are normal, with depths of over 100 inches occurring on the average of once every 10 years. A modifying influence on heavy snowfalls and extreme low temperatures is exercised by the White Mountains, northwest of the Portland area.

Normal precipitation is nearly uniform throughout the year. In March, the record mean (1871-1970) is 3.89 inches, while in August, it is 3.01 inches. Precipitation averages 42 inches.

The conventional forms of transportation are available in the Portland area. Interstate Route 95 is the principal highway link between Portland and other urban centers to the southeast. Railroad freight, scheduled air freight, and passenger services are available in the UMA. The Portland Harbor is one of the busiest east coast oil ports.

## POPULATION

The entire UMA showed an overall increase in population of 3 percent between the years 1960 and 1970. Portland, the major city in the UMA, is the only community whose population declined during the decade of the 60's, reflecting the trend of suburbanization. Portland's 1960 population represented approximately 51 percent of the entire UMA's population, whereas its 1970 population was only about 45 percent of the entire UMA population.

Portland's drop in population did not affect the UMA because of the tremendous population increases of the remaining communities within the UMA. The population of the UMA, excluding Portland, increased by approximately 17 percent during the period 1960-1970. Population projections indicate that the UMA will have about a 45 percent greater population in 2020 than in 1970.

Population data and density for the UMA are given in Table 9, while the expected future trend for population is depicted graphically on Figure 9.

TABLE 9

POPULATION DATA

PORTLAND UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 142.2 | 146.5 | 156.0 | 180.0 | 213.0 |
| Population per square mile | 435 | 450 | 475 | 550 | 650 |

## WATER USAGE

During the mid 1960's, the Portland Water District served approximately 131,200 persons, with an average daily output of 20.5 mgd. Approximately 91 percent of the UMA's total population obtained water from the public system during that period. An estimated 2.0 mgd was provided as publicly-supplied industrial water.

TABLE 10

WATER USAGE

PORTLAND UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 18.5 | 24.2 | 32.3 | 44.8 |
| Publicly-supplied industrial | 2.0 | 3.7 | 7.2 | 12.1 |
| TOTAL M & I | 20.5 | 27.9 | 39.5 | 56.9 |
| Publicly-supplied industrial | 2.0 | 3.7 | 7.2 | 12.1 |
| Self-supplied industrial | 11.7 | 11.7 | 11.7 | 11.7 |
| TOTAL INDUSTRIAL | 13.7 | 15.4 | 18.9 | 23.8 |
| Water Use (gcd) (Based on M & I) | 156.2 | 178.8 | 219.4 | 267.1 |

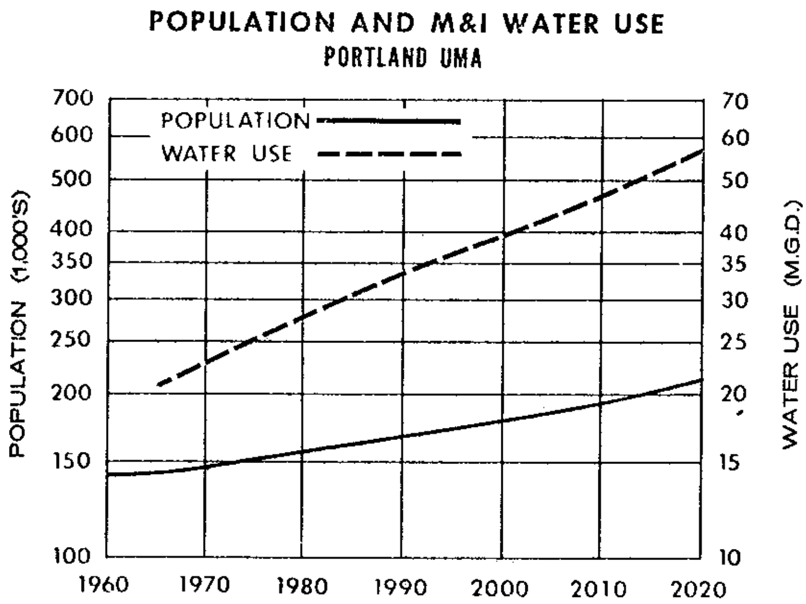



FIGURE 9

The nature of the Portland Water District supports the assumption that future additional industrial water demand of the UMA will be publicly supplied (see Table 10). Therefore, the resultant increase in industrial demand was added to the municipal demand to arrive at the total M & I demand for each benchmark year. Water use projections show that the demand in 2020 will be almost three times as great as that of the mid 1960's, whereas the population increase during that span is slightly less than 50 percent. The trends are depicted graphically in Figure 9.

## KNOWN WATER SUPPLIES

### Summary

The UMA is served almost exclusively by the Portland Water District, a municipal corporation created by the Maine State Legislature in 1907, to supply water service for domestic and commercial uses to the Greater Portland Area.

The greatest asset of the Portland Water District is its principal source of water supply, Sebago Lake, at an altitude sufficient to effect gravity flow throughout most of the UMA. The water is of excellent quality and requires minimal treatment (chlorination) under present conditions. Sebago Lake is about

TABLE 11

KNOWN WATER SUPPLIES

PORTLAND UMA

| System | Mid 1960's Pop Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat Capacity (mgd) | Trans Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Portland Water District | 131,200 | 20 5 | Surface | Sebago Lake | 560 0 1/ | N/A | 50 0 | 50 0 |
| | | | Ground Water | Wells | 2 3 | N/A | N/A | 2 3 |

1/ Safe yield of Lake Sebago is 560 mgd; however, only 300 0 mgd is available for water supply because of the physical arrangement of weirs and intakes

12 miles long with a maximum width of 8 miles, and has a surface area of 46 square miles. The combined surface area of Sebago Lake and its tributaries totals 72 square miles. With a drainage area of 436 square miles, its safe yield has been estimated to be 560 mgd, of which about 300 mgd is available for water supply.

Portions of Cumberland, Standish, and Windham are supplied from five wells operated by the Portland Water District. The wells, collectively having a 2.3 mgd safe yield, have been developed because the areas serviced are located at elevations which do not allow gravity feed from Sebago Lake.

Table 11 lists pertinent data for the Portland Water District, while Figure 10 locates the major physical facilities of the District.

### Future Adequacy

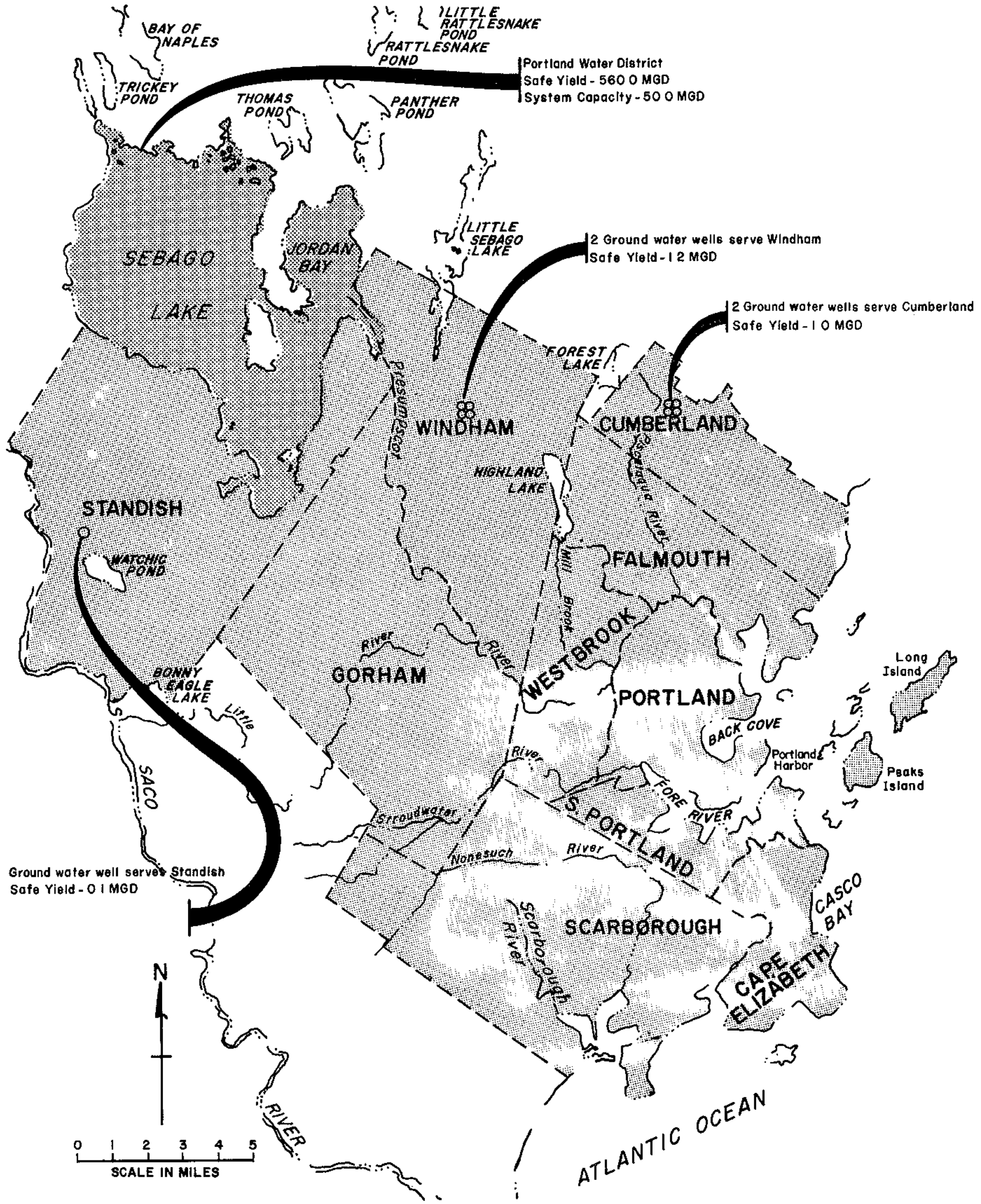
Table 12 compares the projected water demands with the existing capacity of the Portland Water District. The deficit of 4.6 mgd, indicated for the year 2020, reflects the limit of 52.3 mgd imposed by current transmission facilities. Present system capabilities, however, constitute twice present needs, and projected expansion should not be called for until nearly 2010.

TABLE 12

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

PORTLAND UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| M & I Demand | 20.5 | 27.9 | 39.5 | 56.9 |
| Present capacity | 52.3 | 52.3 | 52.3 | 52.3 |
| Deficit | -- | -- | -- | 4.6 |




**KNOWN WATER SUPPLIES**
**PORTLAND UMA**
**FIGURE 10**

With continued intelligent planning by the Portland Water District, and the excellent water supply situation within the UMA, scheduled implementation of measures to update the supply system should prevent any projected deficit from becoming a reality.

## DESIRABILITY FOR REGIONALIZATION

The Portland Water District is fully regional in concept, and utilizes most effectively the existing water supply potential of the area. Continued proper planning and execution should insure trouble-free service for years to come.

Such a regional concept in water supply, as practiced by the Portland UMA, has been a success. The overall water requirements of the area have been met by utilizing available resources in the most effective manner. The Portland Water District should continue to improve its system as it has in the past, to include expansion of transmission capacity as the need arises.

## DEVELOPMENT ALTERNATIVES

The Portland Water District has no foreseeable need for considering additional opportunities for water supply.

## CONCLUSIONS

Although a 4.6 mgd deficit has been indicated for 2020, firm plans for increasing facilities to meet such requirements should prevent any deficit from materializing.

The Portland Water District, with its regional supply, should continue to grow and serve the needs of the entire area. The District's major task will be to regulate development in the Sebago Lake region. The present quality of Sebago Lake water must be preserved to meet the high standards required for water supply. Excessive development on the lake shore may harm water quality to the point where full treatment may be required.

# CHAPTER 5. MANCHESTER-NASHUA

The Manchester-Nashua UMA, located on the northern fringe of the great East Coast "megalopolis", consists of the central cities of Manchester and Nashua, New Hampshire, and the surrounding communities of Goffstown, Bedford, Merrimack, Litchfield, Hollis, Hudson, and Pelham, located in Hillsborough County; Auburn and Londonderry in Rockingham County; and Hooksett in Merrimack County.

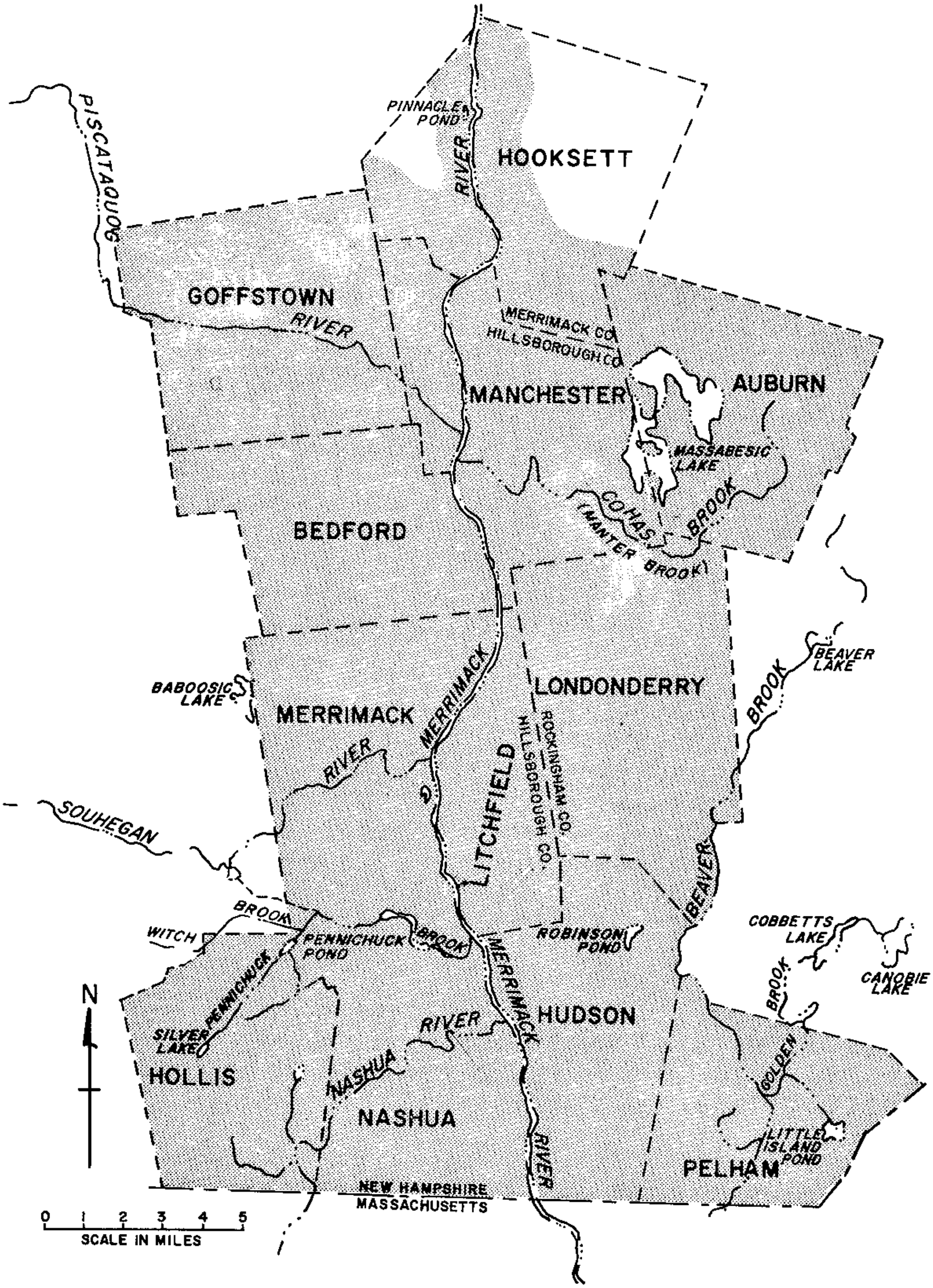
Manchester City is quickly approaching a situation characterized by population saturation, and its suburbs do and will continue to accomodate urban spillover, whereas Nashua City is still growing rapidly, as are its suburbs. The UMA anticipated for the year 2020, with a total land area of nearly 339 square miles, is illustrated on Figure 11.

The UMA lies in the New England Seaboard Lowland physiographic division. It is characterized by streams and rivers flowing at low gradients, and by subdued rolling hills. Higher, isolated, bedrock hills or monadnocks rise above the plain at widely scattered distances. The relief is generally 200 to 400 feet above sea level.

The Merrimack River, the principal topographic feature of the area, traverses the UMA centrally from north to south, and has a drainage area in New Hampshire of nearly 4,000 square miles. The Piscataquog River, a major tributary, joins the Merrimack at Manchester, and has a drainage area of 214 square miles. At Merrimack, the Souhegan River feeds into the Merrimack with a drainage area of 225 square miles. At Nashua, the Nashua River feeds into the Merrimack, with a drainage area of 516 miles.

Lake Massabesic is another major water body in the Manchester area, with surface and drainage areas of 2,560 acres and 47 square miles. In the Nashua area, Pennichuck Pond is dominant. It drains 25 square miles and covers 231 acres.

The climate of the Manchester-Nashua area is generally continental, characterized by comfortable summer temperatures, with only a few days reaching 90°F. Winters are cold, mean




**MANCHESTER-NASHUA UMA**

**FIGURE 11**

monthly temperatures for December through February vary between the low and high 20's. Seasonal snowfall averages approximately 63 inches. Periods of extended drought are a rare occurrence because of the regularity of the precipitation, which averages from approximately 38 inches in the northern part of the UMA to 42 inches in the southern part. It is usually sufficient to insure water supplies for all purposes, if developed. As with most of New England, frequent variation in day to day weather conditions is considered normal.

The centers of population of the UMA are served by a network of main highways and secondary roads. Interstate Route 93 is the principal highway, providing a direct route from Manchester to Boston, Massachusetts. U S. Route 3 and the Everett Turnpike form the highway link between Manchester and Nashua, while U.S. Route 3 continues south from Nashua to connect with the Interstate highway system. Both cities also have good State highways connecting to other areas of the State, and elsewhere.

The Boston and Maine Corporation serves the UMA with rail freight service. The most important line extends from Boston to Lowell, Massachusetts, and then along the banks of the Merrimack River to Nashua, Manchester, and Concord, New Hampshire.

Air traffic is handled by Grenier Field in Manchester. Scheduled flights by Northeast, Mohawk, and Executive Airlines link the UMA with major eastern and Great Lakes region cities. Smaller airports, serving municipal air transportation, are located in Nashua and Hooksett.

The present concentration of urban development covers nearly 30 square miles in the cities of Manchester and Nashua. These cities are industrial centers, among the first to be established in New Hampshire. They have evolved from the agricultural and lumbering-based economy of the early settlements to modern trade specialization centers in the production of textiles, leather goods, and machinery.

Manchester, New Hampshire's largest city, is situated on the Merrimack River at the mouth of the Piscataquog River, a short distance downstream from the Amoskeag Falls (55 feet high). The falls provide a great well of water power, made available by means of canals, for manufacturing. For an extensive period in the city's history, the largest industry was the manufacture of cotton and woolen goods; indeed, for many years the mills of the Amoskeag Manufacturing Company were considered to be the largest cotton manufacturing plant in the world. However, shrinking markets, foreign competition, and the advent of low-priced silk and rayon caused the shut-down of the plant following the depression of 1929.

The economic failure of this plant (which, at its peak, had employed some 15,000 workers), threatened severe consequences for the overall stability of the area. Local businessmen, determined to save this valuable industry for the city, purchased the plant and leased part of it to scores of small firms, which have since operated successfully. Manchester has in recent years experienced a vast decline in its textile industry, but the decline is apparently being offset by a shift of employment emphasis to the growing electrical industry. Other products currently manufactured in Manchester are rubber, automobile accessories, electrical instruments, beverages, dairy products, and confectionery.

The growing city of Nashua is a vast manufacturing area. With the post-World War II withdrawal of the textile industry, the city developed a diversified industrial base through the Nashua-New Hampshire Foundation. Its manufactured products now include shoes, paper products, electronics, chemicals, office equipment, millwork, asbestos products, and plastics. Nashua is also the location of a Federal fish hatchery which operates huge rearing ponds.

Nashua's industrial history deserves note, because some important "firsts" in American industry occurred here. Machine tools and lathes were developed between 1835 and 1852. It was in Nashua that Elias Howe perfected the sewing machine in 1844. The first watches made by machine were produced about 1860, and the first waxed wrappers for bread were commercially produced in 1908.

For the UMA as a whole, employment in the manufacturing industry is expected to grow 40 percent faster than the North Atlantic Region's average, and textiles will continue to employ a fair share of the total employment, approximately three times the North Atlantic Region's average.

## POPULATION

The Manchester-Nashua UMA is one of the most rapidly increasing population regions in the NEWS Study Area. It is one of the few places that are expected to acquire a higher relative share of the nation's population and income within the time frame of the study. The projected growth is due to the area's proximity to the densely populated metropolitan Boston, Massachusetts, area just to the south, and to the anticipated population "spillover" that is taking place now and is expected to accelerate gradually in the future.

The Manchester-Nashua UMA's population increased almost 13 percent in the decade between 1960 and 1970. The city of Manchester itself suffered a slight decrease in population during the sixties whereas the city of Nashua had a 43 percent increase. Projections indicate that the UMA population will more than double in the next 50 years.

The population and density data for the UMA are given in Table 13.

TABLE 13

POPULATION DATA

MANCHESTER-NASHUA UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 159.6 | 200.3 | 225.0 | 360.0 | 426.0 |
| Population per square mile | 470 | 590 | 665 | 1060 | 1255 |

## WATER USAGE

Available data indicate that eight water utilities, operating within the UMA, served approximately 149,700 persons, or about 83 percent of the UMA's population in the mid 1960's with an average daily output of approximately 20.3 mgd. Approximately

20 percent of the average daily output was supplied to industrial users. The water use projections for the benchmark years, 1980, 2000, and 2020 are shown in Table 14.

Because of the lack of good quality water supply sources in the area, industrial demands of the future are expected to be met from publicly supplied water. Good quality water is obtainable from the major water utilities.

Trends of population and water use are shown on Figure 12.

## KNOWN WATER SUPPLIES

### Summary

Water service in the UMA is dominated by two major utilities, the publicly owned Manchester Water Works and the privately owned Pennichuck Water Works. The Manchester Water Works serves Manchester and portions of Goffstown, Hooksett, Bedford, Auburn, and Londonderry. The Pennichuck Water Works, on the other hand, primarily serves Nashua only, with a very few customers in Milford, an adjacent town to the northwest. These two major utilities provided about 87 percent of the total publicly supplied water in the mid 1960's, or about 17.7 mgd.

Six smaller utilities are also located within the UMA· Central Hooksett Village Water Precinct, Goffstown Village Precinct, Hooksett Village Water Precinct, Merrimack Water District, Reed's Ferry Water and Sewer District, and the Hudson Water Company. Pertinent data on the major systems are given in Table 15.

#### Manchester Water Works.

The Manchester Water Works is presently supplied by Lake Massabesic, safe yield of which is approximately 22.0 mgd. The 1965 output of the system was 12.99 mgd (59 percent of capacity); this increased to 14.31 mgd (66 percent of capacity) in 1970. The development goal of the Manchester Water Works has been to serve not only Manchester but also its neighbors. Distribution mains initially were carried toward each of the surrounding cities, terminating at the Manchester city boundary.

TABLE 14

WATER USAGE

MANCHESTER-NASHUA UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 16.3 | 26.0 | 45.4 | 61.9 |
| Publicly-supplied industrial | 4.0 | 7.4 | 15.3 | 27.9 |
| TOTAL M & I | 20.3 | 33.4 | 60.7 | 89.8 |
| Publicly-supplied industrial | 4.0 | 7.4 | 15.3 | 27.9 |
| Self-supplied industrial | 39.3 | 39.3 | 39.3 | 39.3 |
| TOTAL INDUSTRIAL | 43.3 | 46.7 | 54.6 | 67.2 |
| Water Use (gcd) (Based on M & I) | 135.6 | 148.4 | 168.6 | 210.8 |

POPULATION AND M&I WATER USE
MANCHESTER-NASHUA UMA

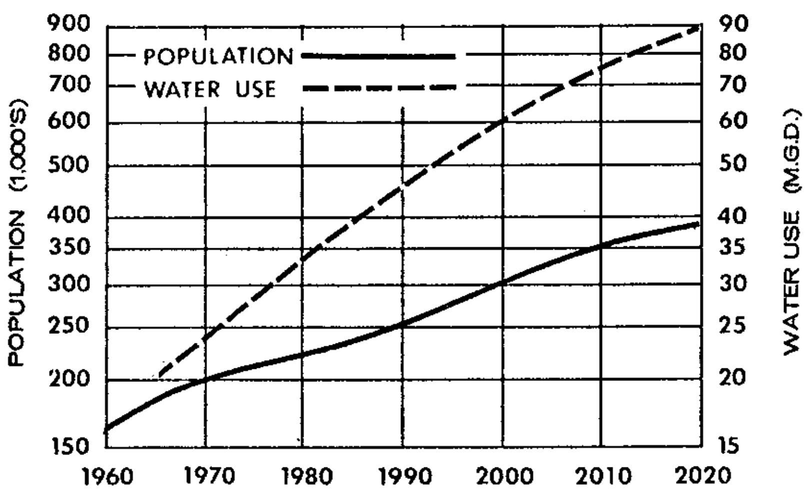
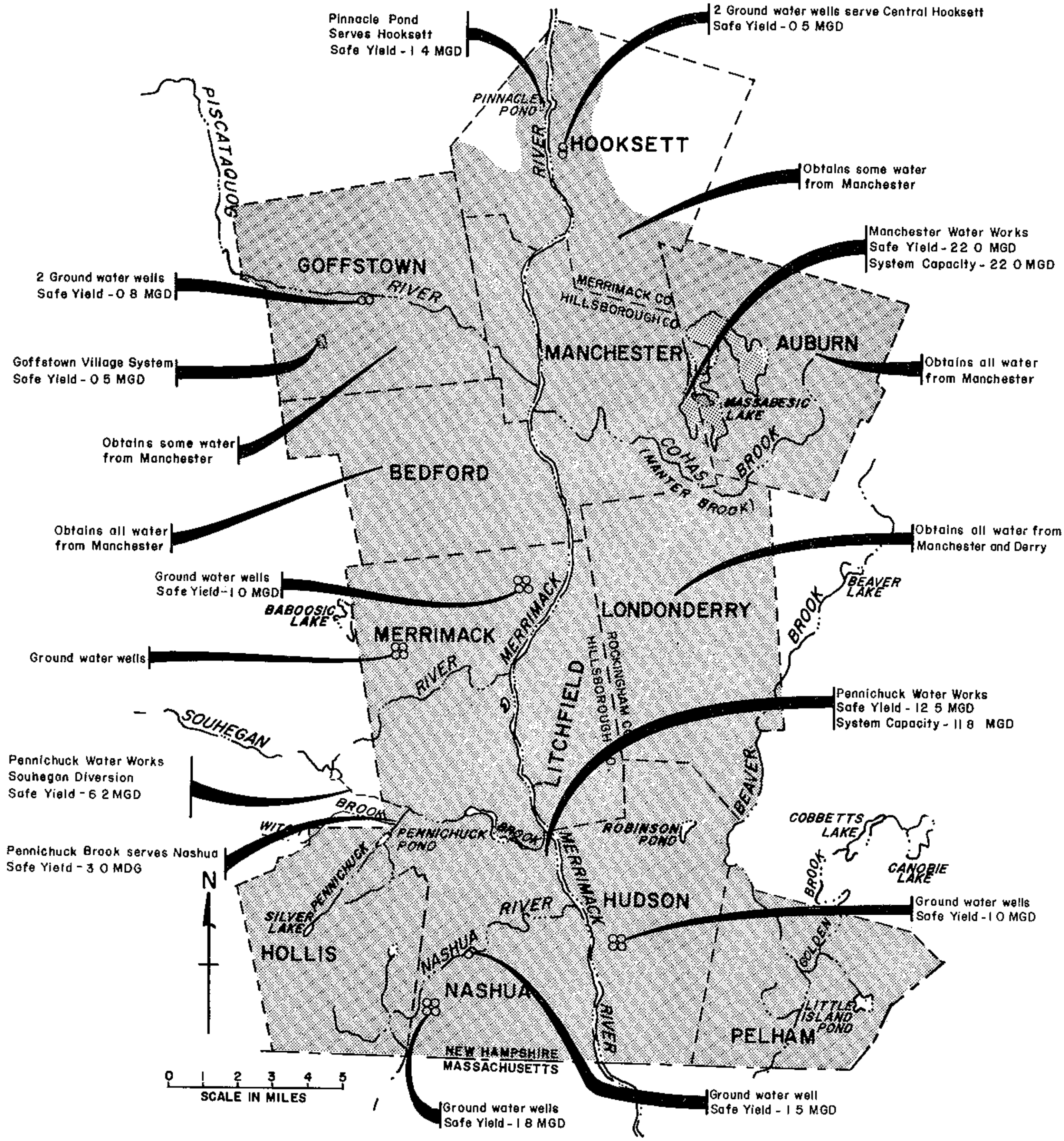



FIGURE 12




**KNOWN WATER SUPPLIES**
**MANCHESTER-NASHUA UMA**
**FIGURE 13**

Anderson-Nichols & Co Inc

TABLE 15

KNOWN WATER SUPPLIES

MANCHESTER-NASHUA UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Mahchester Water Works[1/] | 100,000 | 12 99 | Surface | Lake Massabesic | 22 0 | - | -- | 22 0 |
| Pennichuck Water Works | 41,500 | 6 17 | Surface | Pennichuck Brook | 3.0 | -- | -- | 11.8 |
| | | | Surface | Souhegan River | 5 5 | | | |
| | | | Ground Water | Wells | 3.3 | | | |

1/ Serves Manchester, Auburn, Hooksett, Bedford, Goffstown and Londonderry.

The present plan of the Manchester Water Works is ultimately to increase the maximum capacity of the system to between 50 and 60 mgd. The yield of the system can be increased almost immediately by 3.0 mgd through diversion of spring flows from Cohas Brook (Manter Brook), for which firm plans will be completed by 1975. The water works expects to obtain about 28 to 38 mgd from the Merrimack River in Hooksett, which will be treated at a plant to be located adjacent to Lake Massabesic, and pumped directly into the distribution system.

Pennichuck Water Works.

The Pennichuck Water Works obtains its water from Pennichuck Brook, the Souhegan River, and ground water sources. The total safe yield is approximately 11.8 mgd. In 1965, the output of the system was about 6.2 mgd; this increased to about 9.6 mgd in 1970.

The expanded capacity of the system is the result of diversion from the Souhegan River to Pennichuck Brook which, for two months in 1970, amounted to 5.0 mgd. The Pennichuck Water Works has determined that the safe yield of the Souhegan River, as far as water supply to Nashua is concerned, is 6.2 mgd. Management of the Pennichuck Water Works expects that, by use of the Souhegan River, their system can meet the needs of Nashua for many years to come.

The six smaller utilities together have a total capacity of about 5.2 mgd. One of these systems obtains water from small surface sources and the remaining five are dependent entirely on ground water for their supply. (See Figure 13.)

### Future Adequacy

Future water supply of the UMA is anticipated to be dependent on the two major utilities in the area, the Manchester Water Works and the Pennichuck Water Works. High cost is a prohibitive factor in the development of suitable surface sources by the smaller utilities. Although a number of wells in the Nashua portion of the UMA yield 100 gpm (0.144 mgd) or more, only one well has been found that yields as much as 2.2 mgd. Urbanization is now encroaching on some areas that the USGS has determined to be ground-water favorable, and where nearly all of Nashua's larger wells are located. This might have a serious effect on the surface recharge of the aquifers; however, the aquifers also receive recharge, in part, from adjacent streams.

Smaller communities may be able to afford the lower initial costs of well development, instead of developing surface water sources, and they may be able to offset the annual pumping costs of wells through sales to customers. But, even if a number of very large wells could be developed, the high cost of providing transmission lines from the ground-water favorable areas would prohibit many of the individual communities from developing these sources.

No similar ground water resources study in the Manchester portion of the UMA is available, but the surface geologic characteristics of this part of the UMA do not differ greatly from the Nashua area. However, the possibilities of meeting more than a small part of the total UMA deficits from ground water do not appear to be too promising. It seems reasonable to assume, then, that the required large-scale water resource development for water supply will be accomplished by the two large utilities, the Manchester Water Works and the Pennichuck Water Works, probably from surface sources supplemented by ground water sources.

For these reasons, therefore, only the Mid 1960's capacities of the two major systems were used in determining the water deficits for each of the benchmark years. Comparison of capacity with water demands is given in Table 16.

TABLE 16

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

MANCHESTER-NASHUA UMA

| | 1965 | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 20.3 | 33.4 | 60.7 | 89.8 |
| Present Capability (mgd) | 33.8 | 33.8 | 33.8 | 33.8 |
| Deficit (mgd) | -- | -- | 26.9 | 56.0 |

## DESIRABILITY FOR REGIONALIZATION

The water use projections indicate that by the year 2020 the water supply capabilities of the UMA (Manchester Water Works and Pennichuck Water Works) will have to be increased by approximately 160 percent of the Mid 1960's capacity. This increase can be expected as a result of two factors: first, from the large population increase that would be accompanied by an increase in industry; and, second, from the industrial demand on public water supply. As evidence of this latter aspect, a new brewery, recently established in Merrimack, is obtaining part of its supply from Nashua and part from its own wells.

Since a greater segment of the population undoubtedly will be residing in the suburbs rather than in the central cities of Manchester and Nashua, the water needs of the suburban areas should be expected to increase rapidly. The present smaller utilities will not be able to satisfy the increased demand. Therefore, development of new sources will be required. The lack of available sources of good quality water in ample quantity, which can be developed at reasonable cost, will force these communities to seek alternative methods of obtaining water.

Regionalization seems well suited to develop a water supply network in advance of these needs of the entire UMA. One problem foreseen is how to join the communities together in a region. The municipally owned Manchester Water Works has developed toward regionalization; in fact, it now serves portions of five additional communities. The privately owned Pennichuck Water Works, on the other hand, has developed only to the extent of supplying Nashua.

## DEVELOPMENT ALTERNATIVES

The Manchester-Nashua Urban Metropolitan Area will require an additional 56.0 mgd of water by 2020, as shown in the projections of Table 16. Alternatives for each follow.

### Nashua

Nashua's present system has a potential capacity of 11.8 mgd from the combined resources of Pennichuck Brook (3.0 mgd), Souhegan River (5.5 mgd), and wells (3.3 mgd), as indicated in Table 15. This is probably sufficient until 1980. Development of local resources, including wells and surface supplies (possibly Dunklee Pond and Witch Brook), could increase the capacity to 21 mgd, or to 23 mgd by making needed repairs to gates at Harris Dam. A treatment plant will be required by State regulations to continue use of surface water for public consumption. Although the Merrimack River is of poor quality at present, it is used by Lowell, Lawrence, Methuen, and Billerica (Billerica uses the Concord River, a tributary of the Merrimack River) in Massachusetts, downstream of Nashua. Therefore, by installation of a treatment plant and pumping facilities on the river, the total requirements of the Nashua portion of the UMA could be satisfied. Safe yield of the Merrimack at Nashua is at least 100 mgd, and quality of the Merrimack should improve as anti-pollution measures upstream are instituted.

### Manchester

Manchester's safe yield from Lake Massabesic is 22.0 mgd (see Table 15.) Firm plans of the Manchester Water Works will provide an increase in the safe yield of 3 mgd by 1975, through diversion of spring flows from Cohas Brook (Manter Brook). A cost estimate of this project, based on present day levels, is $250,000.

The Manchester Water Works has completed negotiations with the town of Hooksett for a parcel of land along the Merrimack River. Here they plan to install a pump plant to take water from the Merrimack River, and pump it to a treatment plant to be located adjacent to Lake Massabesic for treatment and distribution directly from the plant. The expected increase in yield from this direct withdrawal will be from 28 to 38 mgd. The treatment plant will have a normal capacity of 20 mgd, with a hydraulic capacity of 40 mgd. The direct withdrawal from the Merrimack River is expected to be in effect between 1980 and 1985.

Assuming that Manchester will increase its yield by 38 mgd, Nashua would need to increase its yield by about 17.3 mgd to supply its portion of the UMA. However, if Nashua's private company should choose not to supply beyond the Nashua city limits, the Manchester Water Works could logically become the regional supply for the remainder of the UMA, and so should seek to develop 50 to 55 mgd additional capacity from the Merrimack, rather than only 28 to 38 mgd.

Manchester-Nashua

A recent statewide water supply study performed by Anderson-Nichols & Company, Inc., for the State of New Hampshire, investigated the possibilities of supply to a much larger area in the Merrimack Basin, including the Concord area to the north of Manchester, as well as the UMA of this study. Two alternative courses of supply were considered, both based on the use of the Merrimack River.

The Plan consisted of a direct intake above Concord with a treatment plant located near Webster. Long transmission lines would serve both sides of the river from above Concord to the Massachusetts border. Because of the assumed need to maintain a 0.2 csm low flow, supplemental raw-water supply would be obtained from an impoundment on the Blackwater River (about 7 miles northwest of Concord). This would require the already existing Federal flood retention dam to be modified to impound 33,000 ac-ft of storage for water supply. Yield of this system is about 185 mgd. Potable water could then be provided to an estimated population of 1,103,000 in 2020 at a first cost of about $174 million.

Subsequent information received from the New England Division, U.S. Army Corps of Engineers concerning the NEWS Study of Eastern Massachusetts - Rhode Island, indicates that a value of 1.2 csm would be a more realistic minimum assumption. This would include both riparian and fish and wildlife as well as the pollution abatement requirements, the latter was the only requirement considered in the present preliminary study. Since completing the feasibility study, the New England Division in its follow-up planning on the Merrimack has recognized these other allied water uses in any formulative plan. Therefore, impact of diversion will be considered, described, and weighed to insure best use of water resources.

The Alternate Plan consisted of constructing 3 treatment plants, one each near Concord, Manchester, and Nashua, for direct withdrawals of water from the Merrimack River. An off-stream pumped-storage site about 5 miles north of Lake Massabesic appears to be ideal for providing necessary storage to supplement the low flows in the river. This storage was also considered necessary in the Alternate to serve a large portion of the Coastal Area of New Hampshire, that is not a part of this NEWS Study. Transmission lines from the storage site would provide additional raw water to the three treatment plants. It would supply an average 187 mgd of water to a population of 1,070,000 in the year 2020. Cost of the Alternate would be $172 million; but annual costs of the Alternate were much higher than those for the Plan.

The populations and the areas to be served differ considerably from those of the UMA. Although the projected population and water demands for the comparable communities do vary, the water demands are in reasonable agreement considering the differences in planning assumptions of the two studies. By scaling down the costs given in the statewide study for the larger area considered, the cost of construction for a regional supply for this UMA might be an estimated $40 million to supply the projected 55.3 mgd deficit in 2020.

The need for regional planning and a single management of water resources has been pointed out in the statewide study. The State's Water Supply and Pollution Control Commission has been suggested as the agency best suited to perform this function.

The other studies under NEWS involve the Merrimack River Basin, which could have an impact on the Manchester-Nashua UMA. First is the Eastern Massachusetts-Rhode Island Water Supply Study made by NEWS, U.S. Army Corps of Engineers, New England Division. Alternatives considered included amounts ranging from 35 mgd to 700 mgd that could be made available from the Merrimack by withdrawals above Lowell, Massachusetts.

The smaller quantities would be transmitted to the surrounding communities, chiefly Lowell and Lawrence, after treatment received at a plant sited above Lowell. The larger quantities would also include augmentation to the systems of Eastern Massachusetts after treatment at a large plant similarly sited at Lowell. Major transmission would be involved if the latter consideration were to be developed. The opportunity of supplying Manchester and Nashua, individually or collectively, is apparent if one considers that neither would be more distant than any of the Eastern Massachusetts communities considered for supply from a proposed treatment plant north of Lowell.

The second study is the Merrimack Wastewater Management Study, also part of NEWS, U.S. Army Corps of Engineers, which involves advanced treatment of all sewerage effluents in the Basin below Lake Winnipesaukee outlet at the Weirs and Franklin, on the mainstem of the river through Haverhill, Massachusetts. Obviously, this proposal does not offer a different opportunity as far as source is concerned. But it would definitely improve the quality of water in the river, enabling withdrawals from almost any point and facilitating serious consideration of various reuses of reclaimed wastewaters. In addition, it should lower the cost of raw-water treatment for any schemes using the Merrimack River as source water.

The New Hampshire Water Supply and Pollution Control Commission published Staff Report No. 56, entitled Merrimack River Basin Plan, in February 1972, that combines schemes similar to the water supply Alternate of the Anderson-Nichols study and those for wastewater treatment developed by the Corps of Engineers in the Merrimack Wastewater Management Study. The cost of this plan, to be accomplished in two parts, is estimated to be $210 million. "Part I is concerned with the entire New Hampshire portion of the Merrimack River Basin.... The concepts in Part II...relate the problem of wastewater treatment to the adequacy of future water supplies for domestic and other uses."

## CONCLUSIONS

Expected increases in public water demand will dictate the development of the additional capacities of at least 26.9 and 56 mgd for the years 2000 and 2020, respectively. Firm local plans indicate that large-scale deficits will never occur. However, an increase in capacity will undoubtedly be needed sometime shortly after 1980. Although Manchester Water Works forms the nucleus of a regional system, Nashua, using a private source, has not yet shown interest in becoming a regional supplier. Local resources may be developed to continue to meet local requirements, but the Merrimack River, conditioned upon quality improvement, offers the best alternative for an adequate supplementary source of all the needs of the UMA in the future. This is true whether the requirements are met by local, State, or Federally involved projects.

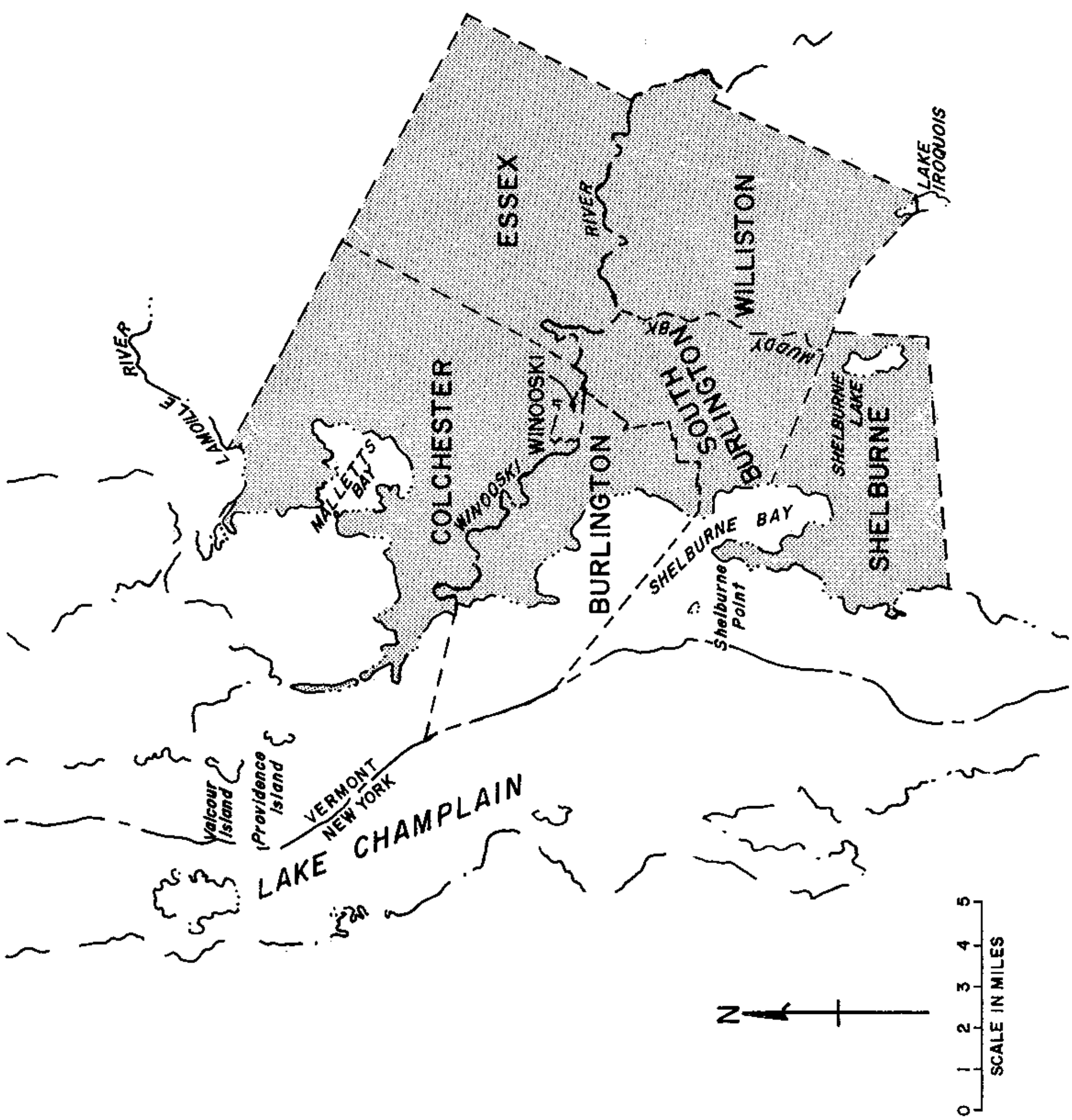
# CHAPTER 6. BURLINGTON

The Burlington Urban Metropolitan Area is the most urbanized area in the State of Vermont and is experiencing rapid growth. Its land area encompasses nearly 176 square miles, as illustrated on Figure 14, and includes the core city of Burlington, and the surrounding communities of South Burlington, Williston, Shelburne, Winooski, Colchester, and Essex.

The Burlington UMA is located in the Champlain Lowland Physiographic Province, on the eastern shore of Lake Champlain. Dominant physical features of the area include Lake Champlain, the Winooski River, and the flat terraces of the Champlain Valley, with occasional monadnocks rising above the valley floor. Elevations range from approximately 95 feet above sea level, at the shore of Lake Champlain, to slightly over 960 feet on Saxon Hill in Essex. On the outer fringes of the UMA, in the towns of Williston and Essex, hills attain elevations of 800 to 1,300 feet.

The most important surface water body is Lake Champlain, utilized for both recreations and public water supply. The Winooski River flows nearly centrally through the UMA. It is used primarily for power generation and wastewater discharge; but because of the discharge, and seasonal low flow, water-borne pollution in the lower part of the river has intensified. This is especially noticeable on weekends, when no power is generated.

The Burlington area climate is characteristic of New England. Summer temperatures are comfortable, with only a few days reaching 90°F. Fall temperatures are cool but pleasant, and usually extend well into October. Winters are cold, with temperatures for December through February averaging in the upper teens. The record extremes are 101°F and -30°F. Because of the shielding effect of the Adirondacks to the west and the Green Mountains to the east, the average precipitation of approximately 33.2 inches is generally less than in other areas of Vermont. Mean snowfall amounts to approximately 75 inches. Frequent variation in day-to-day weather conditions is considered normal.




BURLINGTON UMA

FIGURE 14

Interstate and State of Vermont highways connect the Burlington UMA with the principal Vermont communities, and with the trade centers outside Vermont's borders. U.S. Route 7 provides north-south access along the east side of Lake Champlain, while Interstate 89 supports travel to the north and southeast. U.S. Route 2 connects Burlington with the northeast and provides a northern crossing of Lake Champlain. The Central Vermont and the Vermont Railroads are part of the network providing service to southern New England and northern New York State. Scheduled air freight and passenger service is furnished by Northeastern, Mohawk, and Executive Airlines at Burlington International Airport.

Within the UMA are many institutions of higher education, including the University of Vermont, the State Agricultural College, Trinity College, St. Michael's College, and Champlain College. Burlington is also the location of the State Health Department and Laboratory, and the Medical Center of Vermont, affiliated with the University of Vermont's College of Medicine.

The city of Burlington is noted for metal working, steel fabricating and a variety of manufactured products, including cereal, maple sugar products, plastics, women's clothing, and electrical components. Other items produced in the area are defense and electronic materials, furniture, ceramics, and woodenware. The Burlington UMA, because of Lake Champlain, is also a resort and recreation center.

## POPULATION

The Burlington Urban Metropolitan Area experienced 27 percent population increase during the 1960's. Population projections indicate that the area will continue to grow at a very fast rate, with the 2020 population increasing by 108 percent over 1970 figures.

The population and density data for the UMA are given in Table 17.

TABLE 17

POPULATION DATA

BURLINGTON UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 65.0 | 82.6 | 109.5 | 145.4 | 172.3 |
| Population per square mile | 370 | 470 | 620 | 825 | 980 |

## WATER USAGE

Twelve water utilities presently operate within the UMA, and served approximately 65,500 persons, or almost 90 percent of UMA's population in the mid 1960's. Approximately 73 percent of the water usage, however, was supplied by the area's largest utility, the Burlington Water Department. The average daily output in the mid 1960's was about 6.0 mgd; nearly 2.0 mgd of this went to industrial users.

Industrial water users in the UMA are now finding it almost impossible to develop private systems because there is a lack of good quality water in the area suitable for industrial use. Therefore, it is probable that any new industrial demand in the area would have to be met from publicly supplied water.

The breakdown of the projected water use is reflected in Table 18. The total M & I demand in 2020 will be approximately 19.9 mgd, which is more than 3 times greater than the mid 1960's water usage. Projected water use and population trends are shown on Figure 15.

## KNOWN WATER SUPPLIES

### Summary

Figure 16 shows the existing water supply in the UMA. Of the twelve water utilities in the area, the Burlington Water

TABLE 18

WATER USAGE

BURLINGTON UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 4.0 | 6.9 | 10.3 | 14.4 |
| Publicly-supplied industrial | 2.0 | 2.6 | 3.7 | 5.5 |
| TOTAL M & I | 6.0 | 9.5 | 14.0 | 19.9 |
| Publicly-supplied industrial | 2.0 | 2.6 | 3.7 | 5.5 |
| Self-supplied industrial | 5.8 | 5.8 | 5.8 | 5.8 |
| TOTAL INDUSTRIAL | 7.8 | 8.4 | 9.5 | 11.3 |
| Water Use (gcd) (Based on M & I) | 91.6 | 86.8 | 96.3 | 115.5 |

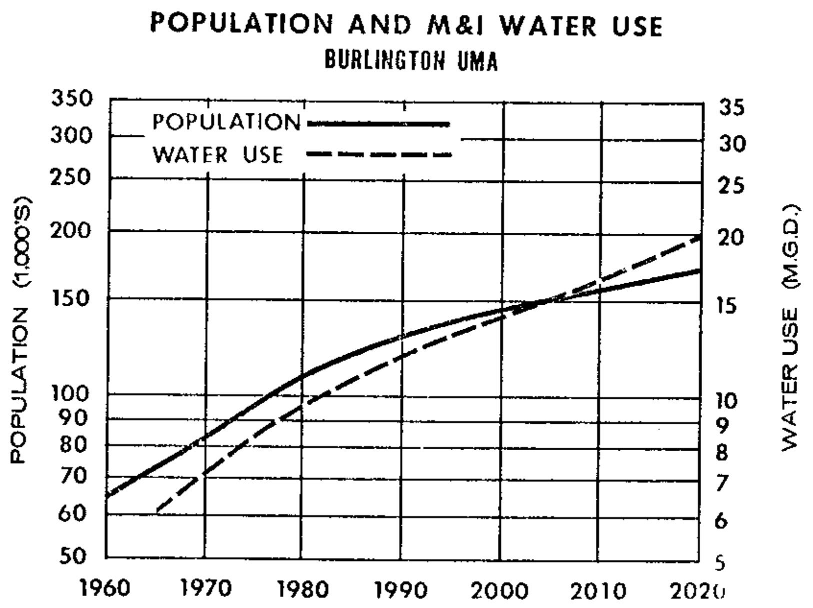
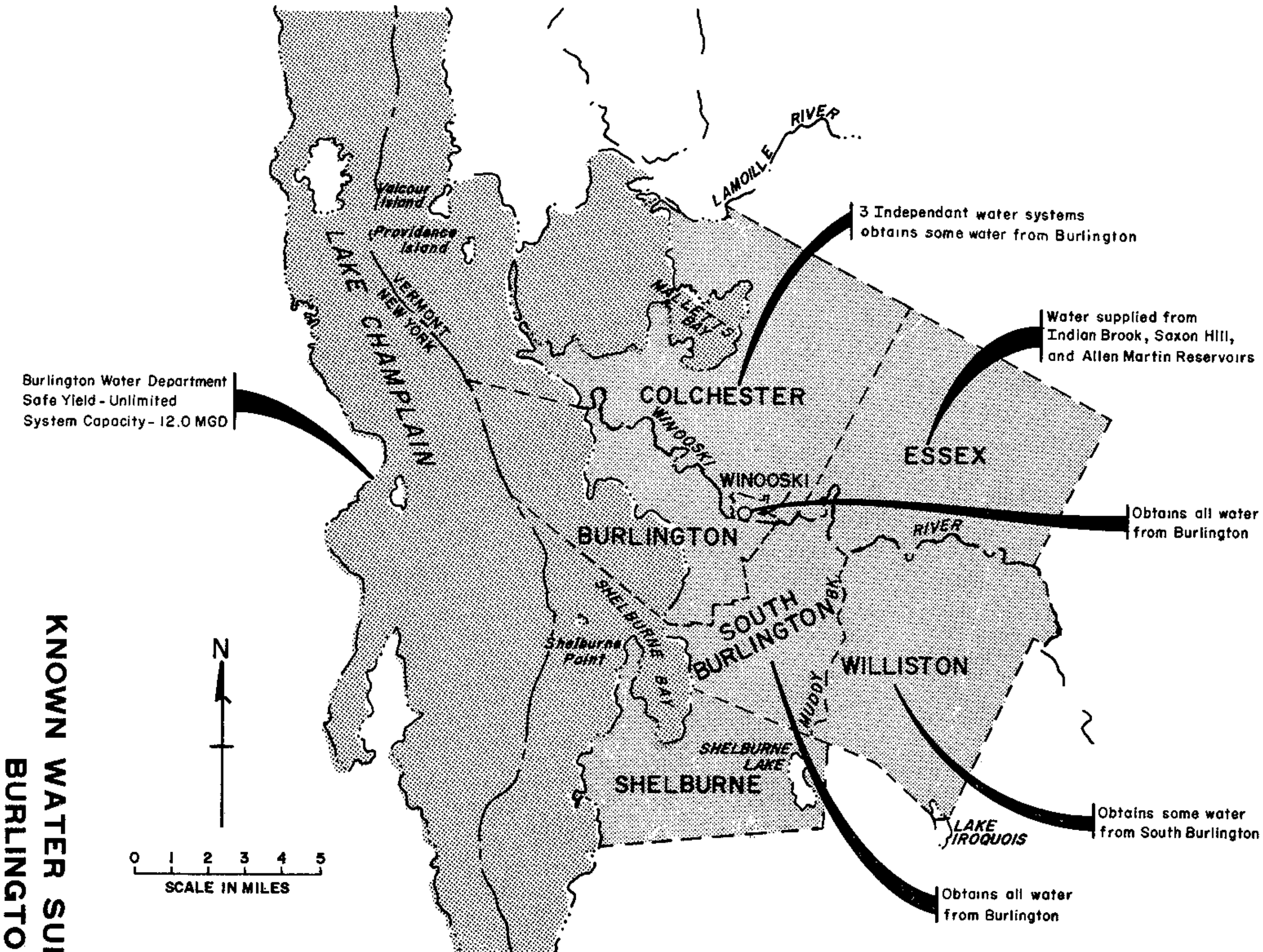



FIGURE 15




# KNOWN WATER SUPPLIES
# BURLINGTON UMA

FIGURE 16

Department was the only major one to serve the UMA in the mid 1960's. The Department is presently supplying water to the following utilities: South Burlington and Winooski Water Departments, Colchester Fire District 2, and the Williston Water Department. Not all of the smaller utilities obtain their water directly from Burlington, but Burlington is the original supplier of the water.

Recently, the Champlain Water District was formed by the following communities: South Burlington, Williston, Essex, Shelburne, and Colchester. Although in its incipient stages, the District has complete plans to meet the water requirements of its member communities. Whenever the Champlain Water District becomes operational by developing its own source, the entire UMA will then be supplied by two major utilities.

Burlington Water Department.

The Burlington Water Department has been growing and operating as a regional water department, supplying water to several communities, and its development has indicated that it plans to continue in this direction. Presumably, however, the creation of the Champlain Water District will result in a decrease in the output of the Burlington Water Department in the future. It appears that the system will lose approximately 30 percent of its 7.0 mgd (1970) output to the Champlain Water District.

The Burlington Water Department obtains its water from Lake Champlain, which affords an unlimited supply of good quality water. An 8.0 mgd treatment plant has just been completed, increasing the treatment capacity to about 16.0 mgd (two 8.0 mgd plants). The limiting factor in the Burlington system is now the 12.0 mgd capacity of the existing intake structure. Another problem facing the Department is that its efficiency may be adversely affected by the ultimate reduction in output.

Based on the present water contracts involving the Burlington Water Department, the Burlington system will probably remain regional in nature for many years to come, and will continue to supply water to the Winooski Water Department and Colchester Fire District 2. With the imminent development of the Champlain Water District, it appears that the Burlington system will be more than adequate for the time frame of this study.

Table 19 contains essential data concerning the Burlington Water Department.

TABLE 19

KNOWN WATER SUPPLIES

BURLINGTON UMA

| System | Mid 1960's Pop Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat Capacity (mgd) | Trans Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Burlington Water Department | 54,000 | 4 33 | Surface | Lake Champlain | unlimited | 16 0 | N/A | 12.0 1/ |

1/ System capacity is limited to 12.0 mgd by the existing intake structure on Lake Champlain

## Champlain Water District.

The Champlain Water District was created in 1966, and now has five active members - South Burlington, Williston, Essex, Shelburne and Colchester. The district was created by the State of Vermont, Department of Water Resources, because very few member communities are adjacent to Lake Champlain, and the more distant communities would require long transmission mains to obtain their water supply. Therefore, the logical solution was for all communities to develop jointly a common water supply system, with Lake Champlain as the source of unlimited, good quality water.

The district plans a 12.0 mgd system in its initial phase of development. The proposed raw water intake is designed to be constructed for the full system capacity of 12.0 mgd, as are the transmission mains. However, the proposed treatment plant and associated pump plants are designed to be constructed initially for a normal capacity of 6.0 mgd, a maximum output of 8.0 mgd. These facilities are easily and economically expanded to achieve the ultimate plant capacity of 12.0 mgd, by adding pumps, filtering systems, and other appurtenances in phased construction. The overall plan of the district includes a second water intake and treatment plant to supply additional water when the total expected demand exceeds 12 mgd.

### Future Adequacy

Table 20 shows that the presently developed capacity will not meet the 2000 demands. The Champlain Water District's proposed facilities were not included in the existing system capacity used in arriving at the benchmark year deficits, however. This new water district plans to be in operation in less than two years. When the initial phase of development is completed, the water deficits determined for the entire UMA will be eliminated; but isolated shortages still may occur because of distribution problems.

TABLE 20

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

BURLINGTON UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 6.0 | 9.5 | 14.0 | 19.9 |
| Present Capability (mgd) | 12.0 | 12.0 | 12.0 | 12.0 |
| Deficit (mgd) | -- | -- | 2.0 | 7.9 |

## DESIRABILITY FOR REGIONALIZATION

The Burlington UMA is an excellent example of an area in which a regional approach to future water supply is the most logical and reasonably available alternative. The proximity of Lake Champlain, the only large source of suitable quality water in the area, makes joint development of the source very practical. Because most of the communities are still small but growing, and are not situated directly on Lake Champlain, long individual transmission lines would be required for each to develop its own supply. Undoubtedly such construction would be a tremendous burden, if not an impossibility, for these smaller communities.

For years the smaller communities have met their water supply needs in several ways: private wells, community well fields, direct intake from Lake Champlain, or from the Burlington Water Department.

In 1966, the Engineering Planning Division, Vermont Department of Water Resources, implanted the idea of a regional approach to water supply. A few farsighted individuals of the UMA recognized the merit of such an approach to best meet their needs, and so formed the Champlain Water District, with five communities in membership.

Apparently the UMA will eventually be served by two collective water supply systems, the Burlington Water Department and the Champlain Water District. Although this is perhaps not the ideal situation, it is far better than seven individual systems. The two major systems can, by close cooperation, insure the more remote communities of the UMA with the excellent water supply now enjoyed by those located nearer Lake Champlain.

## DEVELOPMENT ALTERNATIVES

Obviously, utilization of the almost unlimited water supply potential of Lake Champlain must represent the principal opportunity for the Burlington UMA for water supply. Several problems can be anticipated in development of the lake, including who should be responsible for developing the supply facilities, and maintaining surveillance of the lake's quality.

The Winooski River, because of its pollution, does not currently offer much opportunity for economical water supply development. It does have a mean flow of 1050 mgd at Essex Junction, with a record low flow of 15.5 mgd. Should the quality ever be improved sufficiently for potential water supply, the quantity certainly seems sufficient for consideration as a potential source. Under present conditions, however, the treatment costs would probably be prohibitive.

Ground water investigations were conducted by the Champlain Water District to determine whether an economical source of ground water was available until such time as the total system demand would economically justify the development of Lake Champlain as the source of water. The investigations were successful in locating the quantities of water required for the interim supply; however, the high cost for treatment, under present conditions, makes the development of the interim source too expensive, compared to Lake Champlain.

Without further development of the principal unlimited source, Lake Champlain, deficits of 2.0 and 7.9 mgd in 2000 and 2020, respectively, would occur. However, the capacity will be increased by an additional 6 mgd and be easily expandable to 12 mgd, within 2 years. Thus, no projected deficit should ever be experienced.

## CONCLUSIONS

The development of one regional system to serve the entire UMA, with the existing Burlington facility as its nucleus, would be the most effective means of anticipating the future water supply problem. However, current political restraints make single management an impossibility. Therefore, the Burlington Water Department and Champlain Water District should review jointly their systems and plans, and should construct additional interconnections for their mutual benefit. Initially, interconnection could serve emergency situations, but later, might reduce the required capacity of either water system. Burlington and Champlain must also develop procedures that will insure the continued high quality of Lake Champlain.

By maintaining its existing supply system, the Burlington Water Department will continue to provide adequate water for its customers; no further development of source, treatment or transmission facilities seems necessary. The Champlain Water District should follow through on its plan to construct an intake in Shelburne Bay (Lake Champlain) and a transmission network, thus insuring adequate water for the UMA. If the present plans of the Champlain Water District fail to materialize, however, the only action capable of assuring maximum utilization of natural resources and existing structures would be the expansion of the present intake facility in Lake Champlain by the Burlington Water Department.

# CHAPTER 7. PITTSFIELD

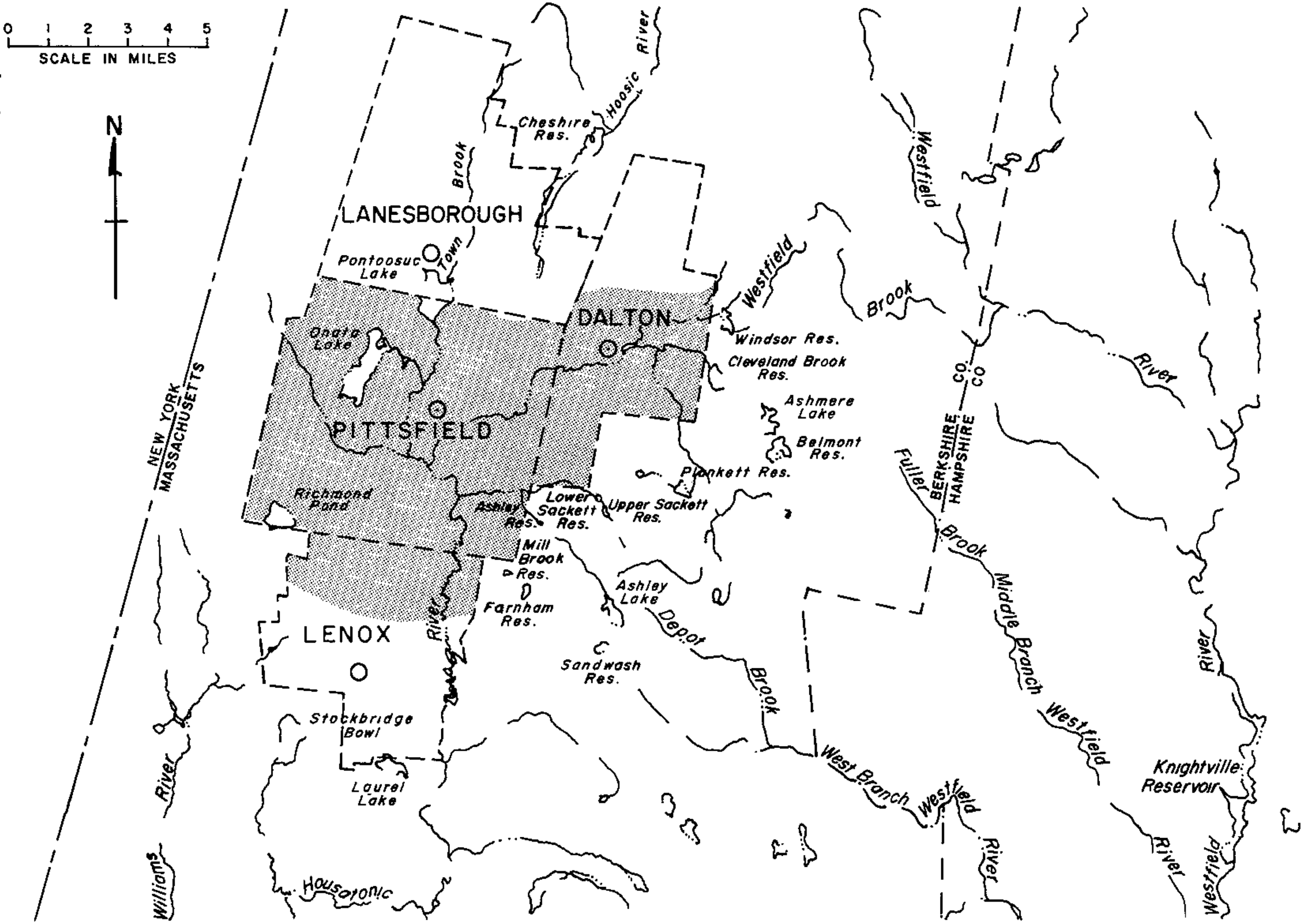
The Pittsfield Urban Metropolitan Area comprises approximately 55.0 square miles of Berkshire County, Massachusetts. The UMA consists of the city of Pittsfield, and portions of neighboring Dalton and Lenox. Future urban development is expected to be limited to the city, and those areas of Dalton and Lenox immediately adjacent to it. The UMA is shown on Figure 17.

The central portion of Pittsfield is fairly flat, approximately 1,000 feet above mean sea level. Outside the center of the city, swamplands and steep hills dominate, with a maximum elevation of 2,000 feet.

Pittsfield's climate is classified as humid-continental. Normal precipitation amounts to about 44 inches, while snowfall is generally about 80 inches. Normal monthly temperatures range from 22°F in January to 68°F in July, with a mean temperature of about 43°F. Relative humidity averages 70 percent, with prevailing winds from the northwest.

Rail, bus, and air transportation facilities are available. Although no interstate highways pass through the city, Interstate Route 90 runs in an east-west direction approximately 10 miles to the south. U.S. Routes 7 and 20 provide access to other New England and New York cities. The Penn Central Railroad and various trucking lines are available for freight service. The city also has a municipal airport, with scheduled flights on Yankee Airlines.

Pittsfield has been one of the largest industrial cities in Massachusetts, and is considered at present to be the principal manufacturing center in the western part of the state. Major industries produce electrical and non-electrical machinery, ordnance, and paper products. Tourist and recreational facilities have been developing at a rapid pace recently, and are expected to play a strong part in Berkshire County's future economy.




Anderson-Nichols & Co Inc

**PITTSFIELD UMA**
**FIGURE 17**

The predominant industry in the UMA is the design, manufacture, and sale of electronic and electrical apparatus. Specialized service industries catering to tourism and recreation also employ a large proportion of the work force. Other important industries are paper and paper making machinery. The textile industry, which once was the mainstay of the area's economy, has declined considerably in recent years.

General Electric is the largest manufacturer in the UMA. Its several plants make such diverse items as electric and electronic equipment, transformers, ordnance, guidance systems, and chemicals. Crane and Company of Dalton manufactures currency paper for the Federal Government; the Eaton Paper Company, located in Pittsfield, is one of the largest producers of stationery in the United States.

## POPULATION

The city of Pittsfield is the core city of the UMA and, in fact, is the only community that is located entirely within the UMA. Small portions of Dalton and Lenox were included because they obtain water from the Pittsfield Water Department. The populations included in the UMA in the towns of Lenox and Dalton were approximated, and are a very small portion of the total UMA population. Therefore, all population projection trends are based on the Pittsfield City potential only.

According to U.S. Bureau of Census data, Pittsfield's population declined during the sixties, showing a 1.5 percent decrease in 1970 over the 1960 figure. Population projections indicate that the UMA will experience only moderate growth during the time frame of this study. The estimated 2020 population for the UMA represents only an 18 percent increase over the 1970 population.

Population figures and resulting densities for the various benchmark years are listed in Table 21.

TABLE 21

POPULATION DATA

PITTSFIELD UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 57.9 | 57.0 | 59.0 | 63.5 | 68.1 |
| Population per square mile | 1055 | 1035 | 1075 | 1155 | 1240 |

## WATER USAGE

Available data indicate that the Pittsfield Water Department served approximately 55,500 persons, or over 95% of the population in 1965, with an average output of 12.9 mgd. Because both the economic outlook and population projections indicate that the area will not grow significantly, water demands are not expected to change. In the event of greater future production than now anticipated, increases in water usage should be met by improved technology and by water conservation practices of the industries. The water use projections show that the total water demand in the UMA will be about 43% greater than the mid 1960's demand.

The water usage data, and the trends of population and water use are shown on Table 22 and Figure 18, respectively.

## KNOWN WATER SUPPLIES

### Summary

The Pittsfield Water Department is the only water utility in the UMA. It relies on three upland reservoir systems for its source of water· Mill Brook, Ashley and Cleveland. Each is chlorinated and flows by gravity into the distribution system.

The Cleveland Brook Reservoir system is the most important present source. Located in Hinsdale, it has a safe yield

TABLE 22

WATER USAGE

PITTSFIELD UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 6.5 | 7.7 | 9.5 | 12.0 |
| Publicly-supplied industrial | 6.4 | 6.4 | 6.4 | 6.4 |
| TOTAL M & I | 12.9 | 14.1 | 15.9 | 18.4 |
| Publicly-supplied industrial | 6.4 | 6.4 | 6.4 | 6.4 |
| Self-supplied industrial | 8.0 | 8.0 | 8.0 | 8.0 |
| TOTAL INDUSTRIAL | 14.4 | 14.4 | 14.4 | 14.4 |
| Water Use (gcd) (Based on M & I) | 232.0 | 239.0 | 250.0 | 270.0 |

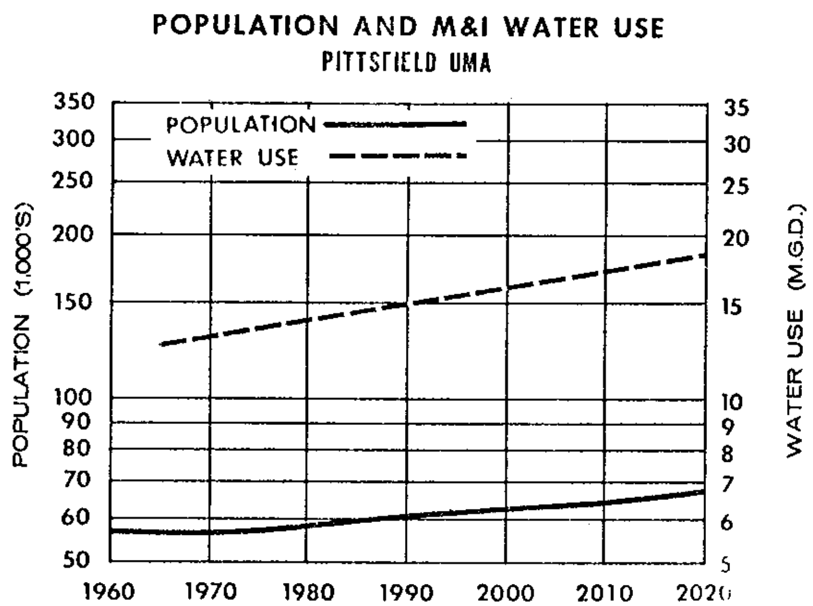
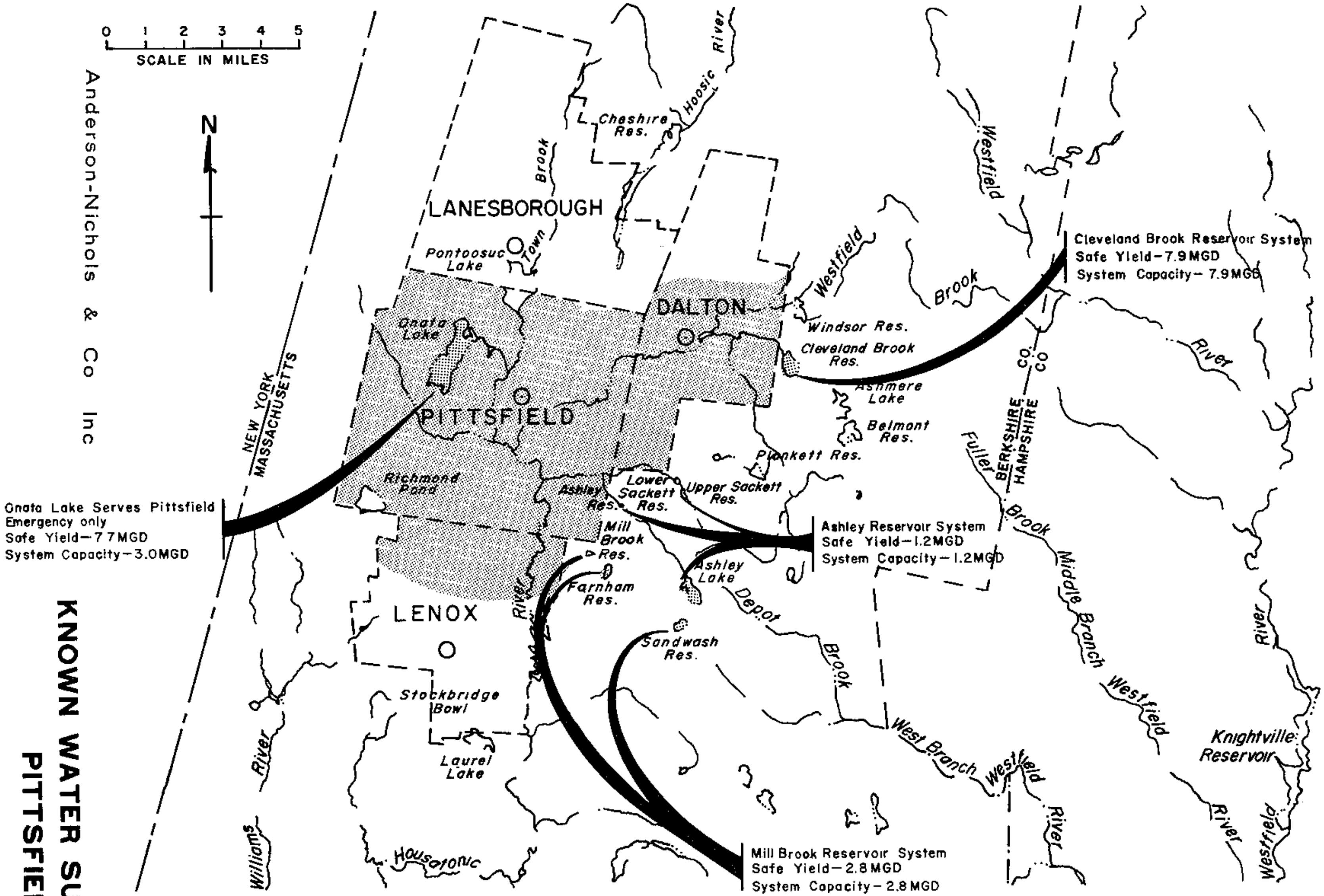



FIGURE 18

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**KNOWN WATER SUPPLIES**
**PITTSFIELD UMA**

**FIGURE 19**

TABLE 23

KNOWN WATER SUPPLIES

PITTSFIELD UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat.[1/] Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Pittsfield Water Department | 55,500 | 12 9 | Surface | Cleveland Brook Reservoir | 7.9 | N/A | N/A | 7.9 |
| | | | Surface | Farnham Reservoir | 1.8 | N/A | N/A | 1.8 |
| | | | Surface | Sandwash Reservoir | 1.0 | N/A | N/A | 1.0 |
| | | | Surface | Sackett Reservoir | 0.6 | N/A | N/A | 0.6 |
| | | | Surface | Ashley Lake | 0.5 | N/A | N/A | 0.5 |
| | | | Surface | New Ashley Reservoir | 0.1 | N/A | N/A | 0.1 |
| | | | Surface | Onota Lake | 7.7 | N/A | N/A | 3.0[2/] |

1/All supplies are disinfected
2/Applies to pumping capacity on an emergency basis only.

of about 7.9 mgd. The town of Dalton has the right to tap this system of up to 1.5 mgd, because the town granted rights for a transmission main to pass through its land.

The Mill Brook system, from which parts of Lenox are served, consists of the Mill Brook, Sandwash, and Farnham Reservoirs. Located in the town of Washington, it has a safe yield of 2.8 mgd. Its transmission system joins that from Ashley Reservoir.

The Ashley system consists of Ashley Lake in Washington, Sackett Reservoir in Hinsdale, and the new Ashley Reservoir in the southwest corner of Dalton. The total safe yield of these reservoirs is about 1.2 mgd.

The capacity of the Pittsfield System has been increased to 14.9 mgd during emergency periods, such as the drought of 1964-1965, by using 3.0 mgd from Onota Lake, located on Pittsfield's western border. Existing pumping facilities on the eastern shore of the lake have a capacity of 3 mgd.

Data pertinent to these sources are presented in Table 23, and shown graphically on Figure 19.

Future Adequacy

The adequacy of the present system, compared to the projected water demands, is shown in Table 24.

TABLE 24

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

PITTSFIELD UMA

| | 1965 | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 12.9 | 14.1 | 15.9 | 18.4 |
| Present Capability (mgd) | 14.9 1/ | 14.9 | 14.9 | 14.9 |
| Deficit (mgd) | -- | -- | 1.0 | 3.5 |

1/Includes 3.0 mgd emergency supply capability of Lake Onota, but available only upon approval of the Massachusetts Department of Public Health for a six-month period, unless the city applies for an extension.

The projected growth rate of the Pittsfield UMA shows no rapid increase in population. In fact, some projections have reflected a decline, rather than an increase in the future population of the area. A potential water shortage problem faces Pittsfield until attempts to acquire full rights to Ononta Lake by the Pittsfield Water Department are settled. Only in the event that the acquisition is unsuccessful must other sources be developed rapidly. Because the Massachusetts Department of Public Health controls emergency use of Ononta for Pittsfield water supply, it does not seem reasonable to assume that this source will be denied until other sources are available. Nor does it appear necessary for the Pittsfield Water Department to consider expansion of its services to other communities, thereby forcing itself into a search for additional sources that are rather scarce in the immediate area.

## DESIRABILITY FOR REGIONALIZATION

The entire UMA actually has a regional water supply, at present - the Pittsfield Water Department. However, Pittsfield serves the two neighboring communities not out of interest in being a regional supplier, but rather for convenience, in the case of Lenox, and as payment for right-of-way of a pipeline through parts of Dalton.

## DEVELOPMENT ALTERNATIVES

Despite the fact that the water supply situation of the Pittsfield Water Department does not appear to be critical, the projections indicate that a shortage will occur before the year 1990, even if the 3 mgd obtained from Onota Lake are utilized. Therefore, the Pittsfield Water Department should seek additional sources as soon as possible to insure that the people of Pittsfield continue to obtain good quality water in ample quantity. The water supply consultants for Pittsfield have proposed reasonable alternatives, including the development of upland surface water sources, as follow·

### Onota Lake.

The safe yield of Onota Lake is approximately 7.7 mgd; presently only 3.0 mgd is used for water supply during emergencies. The additional 4.7 mgd would satisfy the needs of the UMA well past the year 2020. The City of Pittsfield has a proposal to acquire the water rights of this lake, but Onota has become a recreational lake with much surrounding development. Therefore, acquiring Onota Lake may be a difficult undertaking, and might perhaps alienate many people.

From a purely engineering standpoint, acquisition of this lake would be a good and feasible method of increasing the systems capacity of the Pittsfield Water Department. The lake is an excellent source; it is already a part of the Pittsfield system; and it would satisfy water needs until after 2020. The pumping facilities at the lake would have to be increased to a capacity of approximately 10 mgd.

### Westfield Brook Diversion.

By means of a special act passed by the Massachusetts Legislature in June, 1968, an agreement has been reached to develop an additional water supply source in the town of Windsor. The proposed project includes a diversion dam and pumping station on Westfield Brook, which is a tributary to Westfield River in the Connecticut River Basin. A pipeline would extend from the pumping station to a second impoundment on Windsor Brook, approximately 2,000 feet from Route 9. The pumping station would operate only on a limited basis each year, at which time the Town of Windsor would be permitted to take water from the main for fire protection. Since the project involves interbasin transfer (Westfield River Basin into the Housatonic River Basin), the Massachusetts Water Resources Commission and the Division of Fisheries and Game will only allow removal from Westfield Brook when flows in the brook exceed 0.71 mgd. The Westfield Brook Diversion would increase the yield of the Pittsfield system by approximately 2.1 mgd.

### Savoy-Windsor Project.

A second proposed upland surface water source, Savoy-Windsor Project, would increase the yield of the Pittsfield system by approximately 4.5 mgd. This project consists of two diversion dams, pumping station, pipeline and impounding reservoir. One diversion dam would be constructed on Savoy Hollow Brook in Savoy just west of the junction of State Routes 8A and 116. Water from behind this dam would flow through a 20-inch gravity pipeline, to a pool behind a second diversion dam located on Center Brook, about 1/2 mile east of the Savoy Brook diversion.

Water would then be pumped through a 36-inch pipeline to an impounding reservoir located on Windsor Brook, about 1/2 mile northeast of the Town of Windsor. Water would be released from the storage reservoir to flow in Windsor Brook for diversion to the existing Windsor Brook structure, and impoundment in Cleveland Reservoir.

## CONCLUSIONS

The Pittsfield UMA should not experience a water supply shortage until sometime well after 1980. The UMA has a regional water supply, more by circumstance than by design; declining population, should it continue, may make expansion unnecessary. If additional supply sources should be needed, they are available, and can be developed to provide from 2.1 to as much as 4.7 mgd. The possible alternatives include:

1. Onota Lake, from which 3 mgd can be taken now in emergency, and an additional 4.7 mgd if the acquisition of the lake is accomplished.

2. The Westfield Brook Diversion, that would increase Pittsfield's supply by 2.1 mgd; and

3. The Savoy-Windsor Project, a diversion that would increase the supply by 4.5 mgd. The Westfield Brook Diversion alone is insufficient to meet the 2020 projected deficit; however, either of the other alternatives is capable of meeting the total deficit.

(Note: The town of Lenox, part of which is already served by Pittsfield, is known to be experiencing a problem in finding a suitable source to expand its present supply. In analyzing Pittsfield, the problem of the larger remainder of Lenox was also considered. It was not made a part of the previous discussion, since it is outside the UMA. This urban portion of Lenox, about 5 miles south of Pittsfield, is at an elevation of approximately 250 feet above Pittsfield. No source development for Pittsfield in the Lenox vicinity is apparent, and no transmission lines for Pittsfield pass near there. Therefore, the only forseeable solution for Lenox from a Pittsfield source appears to be a 5-mile force main and pumping facility, which might cost roughly about $250,000 dollars for construction, not including annual operation and maintenance costs or debt service. At the time that Pittsfield decides to increase its present capacity, the Lenox problem should be taken into consideration, as the proper size of development might be contingent upon such an additional requirement. The 1965 average water consumption of the entire town of Lenox was about 0.6 mgd. Recent projections, made by the consultant for the Berkshire County Regional Planning Commission, indicate that by 2020 the average water consumption will be about 1.5 mgd.)

# CHAPTER 8. NEW LONDON-GROTON-NORWICH

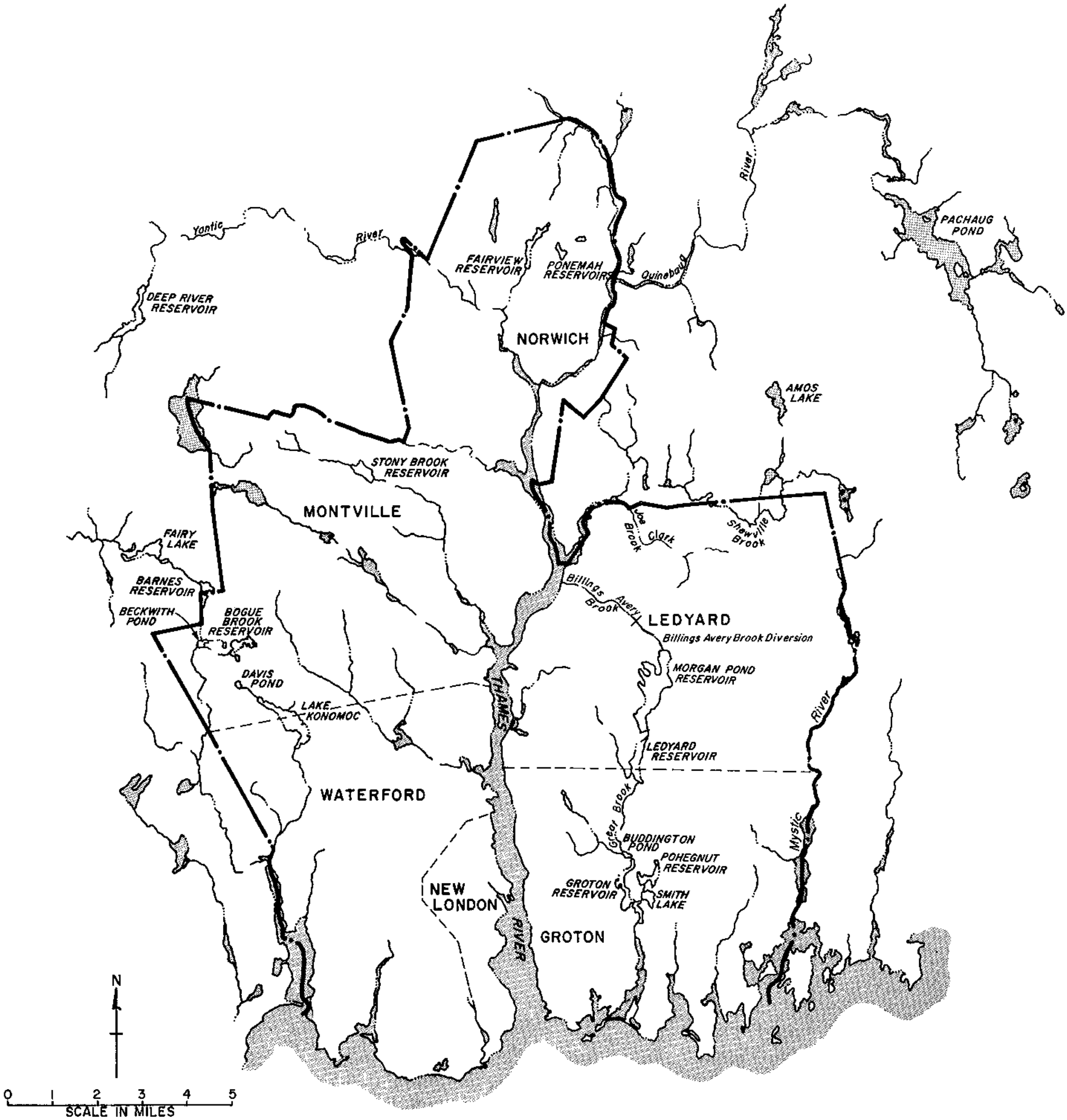
The New London-Groton-Norwich UMA, as shown on Figure 20, is located in southeastern Connecticut, and consists of the communities of Groton, Ledyard, Montville, New London, Norwich, and Waterford. The dominant geographical feature is the Thames River, along which the communities lie. The UMA extends approximately 19 miles north from the mouth of the Thames on Long Island Sound, and is about 15 miles wide. Of irregular shape, it encompasses a total area of slightly less than 200 square miles.

Intensive urban development is presently limited to the three core cities, New London, Groton, and Norwich. The geographic center of the UMA lies approximately 75 miles southwest of Boston, Massachusetts, 100 miles northeast of New York City, 40 miles southwest of Providence, Rhode Island, and 40 miles southeast of Hartford, Connecticut. The location suggests expanding zones of influence, ultimately coinciding with the neighboring urban areas.

The topography of the UMA is characterized by rolling hills, with a general slope toward the Thames River and Long Island Sound. Elevations range from sea level to 600 feet near the western boundaries. Narrow valley streams are common throughout the area.

Climate within the UMA is relatively unpredictable, as is typical of New England, but characterized by bi-weekly snow or rainstorms, that are a result of cyclonic disturbances moving through this region. The average temperature is about 49°F, with extreme monthly averages of 30°F and 40°F, occurring in January and July, respectively. Total precipitation usually amounts to about 47 inches, while mean snowfall is 35 inches. Prevailing winds are from the southwest.

Passenger and freight transportation facilities offer excellent service to local residents and industries. Major highways include Interstate Route 95 and the Connecticut Turnpike. The area is also served by U.S. Route 1 and several State routes.




**NEW LONDON - GROTON - NORWICH UMA**

**FIGURE 20**

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Additionally, all modern modes of transportation, both passenger and freight, are available.

Industrial activity is concentrated in New London, Groton, Montville, and Norwich. Major industrial water users include paper and textile mills, and plastic and chemical companies. Naval installations and shipbuilding facilities employ a large number of both military and civilian personnel in New London and Groton.

## POPULATION

The population of the UMA increased by approximately 21 percent during the 1960's. All towns included within the UMA, with the notable exception of New London, experienced a growth rate of at least 30 percent for the years 1960-1970. The decrease in New London's population, a loss of 8 percent, is a result of urban renewal activities and out-migration. Population projections indicate that the UMA will grow considerably in the next 50 years.

UMA population figures and resulting densities for the various benchmark years are listed in Table 25.

TABLE 25

POPULATION DATA

NEW LONDON-GROTON-NORWICH UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 131.2 | 159.0 | 182.0 | 227.0 | 270.1 |
| Population per square mile | 665 | 805 | 925 | 1150 | 1370 |

## WATER USAGE

Available water use data disclosed that 40 water utilities in the UMA served approximately 106,800 persons, or about 74 percent of the population in 1965, with an average output of about 15.0 mgd. The three major public utilities, Groton Department of Utilities, Norwich Water Division, and City of New London Public Water System provided more than 95 percent of this water service.

The industrial water use for 1965 was estimated to be a total of 24.0 mgd, 8.0 mgd publicly supplied and 16.0 mgd self-supplied. Future increases in industrial demands within the time frame of this study are expected to be supplied by the public utilities, because of the lack of suitable surface sources in the area where industrial development should occur, and/or the high costs involved in testing and developing possible ground-water systems in the area.

The water use projections indicate that the public systems will be required to supply approximately 220 percent more to consumers in the year 2020 than that supplied in 1965. Pertinent water usage data appear in Table 26, and trends are depicted graphically on Figure 21.

## KNOWN WATER SUPPLIES

### Summary

The total capacity of the 40 water supply systems in the UMA is approximately 28.4 mgd, although only three major water utilities supply most of the water. The 37 remaining systems are fairly small, with a combined maximum capacity of about 3.2 mgd, and they differ in extent of service: some provide water to a few dozen mobile homes, while others supply many thousands of customers. The quality of these systems and the service provided range from very good to quite poor. Data pertinent to the three major utilities are presented in Table 27.

#### <u>The New London Public Water Supply System.</u>

The New London Public Water Supply System serves New London and the town of Waterford. In 1965, its average output was

TABLE 26

WATER USAGE

NEW LONDON-GROTON-NORWICH UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 7.9 | 14.0 | 20.0 | 26.9 |
| Publicly-supplied industrial | 8.0 | 10.2 | 15.5 | 24.6 |
| TOTAL M & I | 15.9 | 24.2 | 35.5 | 51.5 |
| Publicly-supplied Industrial | 8.0 | 10.2 | 15.5 | 24.6 |
| Self-supplied industrial | 16.0 | 16.0 | 16.0 | 16.0 |
| TOTAL INDUSTRIAL | 24.0 | 26.2 | 31.5 | 40.6 |
| Water Use (gcd) (Based on M & I) | 149.0 | 133.0 | 157.0 | 190.0 |

POPULATION AND M&I WATER USE

NEW LONDON-GROTON-NORWICH UMA

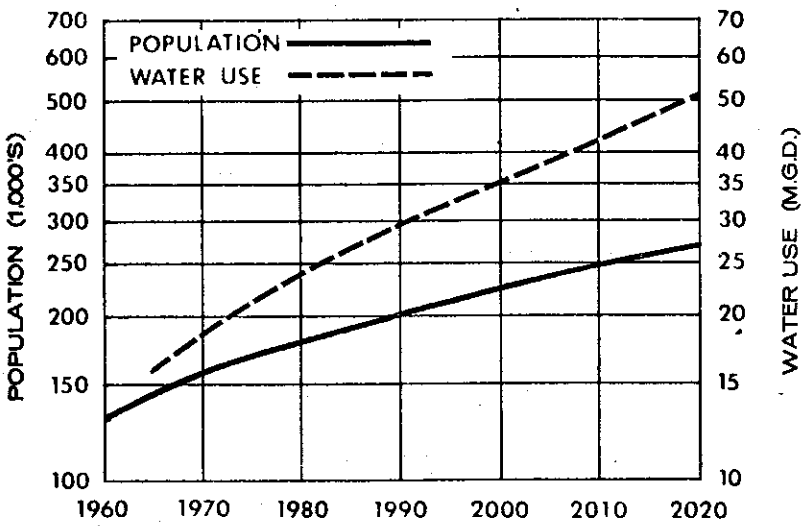



FIGURE 21

3.6 mgd, increasing to about 4.6 mgd in 1968. It has a capacity of 6.45 mgd, with source as the limiting factor. The system derives its water from a network of inter-connected reservoirs which drain four minor watersheds. All water reaches Lake Konomoc, the terminal reservoir, by gravity flow, occasionally supplemented by a booster pump. At the Lake Konomoc pumping station, chlorine is injected into the system for disinfection, "Calgon" treatment is applied, caustic soda is added for pH control, and the supply is fluoridated.

TABLE 27

KNOWN WATER SUPPLIES

NEW LONDON-GROTON-NORWICH UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| New London Public Water Supply System | 36,200 | 3.6 | Surface | Beckwith Pond | 0.61 | 6.45 | N/A | 6.45 |
| | | | Surface | Fairy Lake | 0.95 | | | |
| | | | Surface | Barnes Reservoir | 1.85 | | | |
| | | | Surface | Bogue Brook Reservoir | 1.70 | | | |
| | | | Surface | Lake Konomoc | 1.34 | | | |
| Groton Public Water Supply System | 28,600 | 7.5 | Surface | Billings Avery Brook Diversion | 1.1 | 12-18 | N/A | 12.1 |
| | | | Surface | Morgan Pond Reservoir | 2.5 | | | |
| | | | Surface | Ledyard Reservoir | 1.5 | | | |
| Groton Public Water Supply System (con't) | 28,600 | 7.5 | Surface | Groton Reservoir Buddington Pond Pohegnut Reservoir Smith Lake | 7.0 | | | |
| Norwich Public Water Supply System | 36,200 | 4.1 | Surface | Deep River Reservoir | 3.1 | 6.65 | N/A | 6.65 |
| | | | Surface | Stony Brook Reservoir | 2.5 | | | |
| | | | Surface | Fairview Reservoir | 0.85 | | | |
| | | | Surface | Ponemah Reservoir No. 1 | 0.125 | | | |
| | | | Surface | Ponemah Reservoir No. 2 | 0.075 | | | |

The Groton Public Water Supply System.

This is the largest water supply utility in the UMA. In 1965, its average daily production was approximately 7.5 mgd, increasing to about 9.4 mgd in 1968. The system has a maximum capacity of about 12.1 mgd, with source capability as the limiting factor. Its water comes from the 15.7 square-mile combined watershed of the Great Brook and the Billings Avery Brook. The flow from this watershed is collected in a system of impounding reservoirs: Buddington Pond, Pohegnut Reservoir, Smith Lake, Ledyard Reservoir, and Morgan Pond Reservoir. All are interconnected component sources of supply, which discharge into Groton Reservoir, the lowest in the system. The service area of the Groton Public Water Supply System includes Groton Town, Groton Long Point, and the Noank Fire District. This and other systems are shown on Figure 22.

The treatment plant, located at the south end of Groton Reservoir, has a rated capacity of 12 mgd and a maximum capacity of 18 mgd. Treatment includes corrosion control, filtration, flouridation, and disinfection.

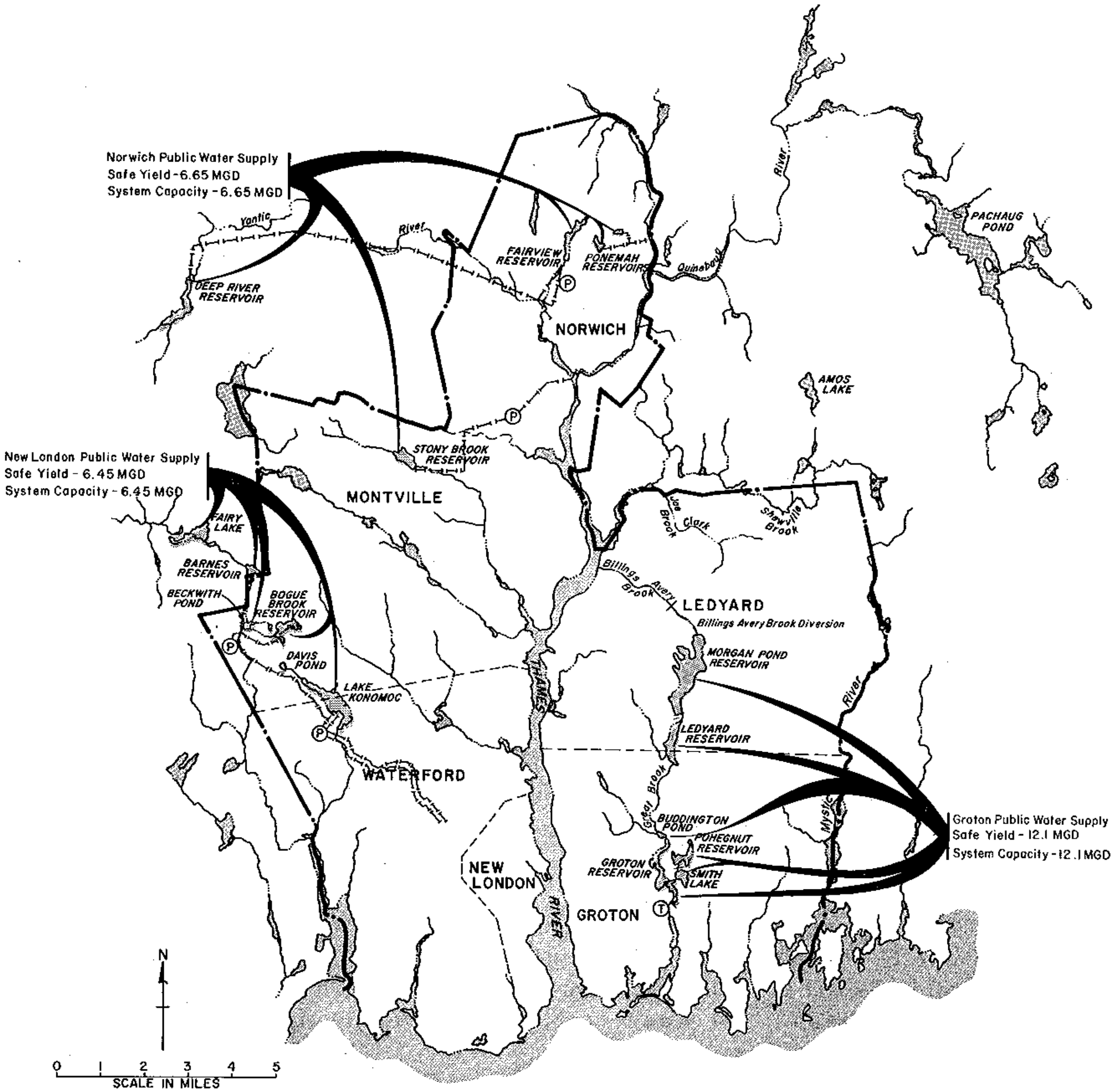
The Norwich Public Water Supply System.

The utility serves not only Norwich, but also Bozrah, Fitchville, Montville, and Lebanon. In 1965, the system supplied 36,200 persons with an average output of about 4.1 mgd, which increased to about 5.0 mgd in 1968. Its capacity is about 6.65 mgd, with source as the limiting factor. The system derives its water from three major surface impounding reservoirs - Deep River, Stony Brook, and Fairview - and two minor ones - the Ponemah Reservoirs, located in Taftville.

The treatment of the Norwich water supply consists of disinfection by chlorination, at the outlet of each reservoir, and in the pumping stations. In addition, a filter plant is now under construction at Deep River Reservoir, and the reservoir is being enlarged.

Future Adequacy

The total capacity of the existing systems within the UMA is about 28.4 mgd. According to projected water demands, shown in Table 26, a deficit in water supply capability will occur shortly before the year 1990. It is important to note, however,




# KNOWN WATER SUPPLIES
# NEW LONDON - GROTON - NORWICH UMA

**FIGURE 22**

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that since about 40 utilities are involved, most not presently inter-connected, the date of the composite deficit for the UMA is misleading. A severe, local deficit could occur much sooner, unless preventive measures are planned and implemented.

The three major utilities at present have no major projects planned that collectively would satisfy the 2020 deficits. The New London system is planning the acquisition of Beckwith Pond and construction of a new dam and pumping facilities at the site. The raising of the present dam and construction of a new pumping station at Lake Konomoc have recently been completed. At this time, the Groton System has no plans for increasing the source capacity of its system. The Norwich system has a program in operation that includes the developing of wells, with a pumping capacity of about 4 mgd, at Norwichtown and upstream along the Yantic River.

The major future water supply problem for the New London-Groton-Norwich UMA exists in the location and development of sources. From Table 28, it is evident that additional sources yielding at least 23 mgd must be developed prior to 2020. As sources of supply are developed, transmission and treatment facilities must be constructed to accommodate the purification and transportation of water to the customers within the UMA. Future transmission and treatment requirements will be of the same order of magnitude as source needs.

TABLE 28

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

NEW LONDON-GROTON-NORWICH UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 15.9 | 24.2 | 35.5 | 51.5 |
| Present Capability (mgd) | 28.4 | 28.4 | 28.4 | 28.4 |
| Deficit | -- | -- | 7.1 | 23.1 |

## DESIRABILITY FOR REGIONALIZATION

The lack of a planned, systematic approach to meet the area's water needs had resulted in a proliferation of small, independently-operated water utilities serving limited portions of the New London-Groton-Norwich Area. The recognition of a need for regionalized planning in the UMA prompted the creation of the Southeastern Connecticut Regional Planning Agency (SCRPA) and the Southeastern Connecticut Water Authority (SCWA). The Authority is charged by statute to plan, operate and maintain a water supply system and, where necessary, construct water supply systems for the SCRPA.

The UMA as delineated in the present study, closely approximates the boundaries of the region called "Thames River Group" in the consultant's study and "Central System" in the 1970 Water Supply Plan of the SCWA and SCRPA. The area includes the three major cities and the three major water utilities in southeastern Connecticut. It is the consensus among planners that regionalization, which would eventually interconnect existing utilities and, therefore, increase the efficiency of the water supply system of the entire UMA, is desirable. Such a regional system would permit development of a common source of additional supply, and a single additional filtration plant. It would also expand the economic base that will bear the financial obligations incurred, and eventually provide opportunity for future residential and economic development.

Because of the current overall water situation in the UMA, including the creation of the SCWA, a regional approach is anticipated to provide the additional 23.1 mgd of water that will be needed to meet the projected 2020 demands.

## DEVELOPMENT ALTERNATIVES

There have been many studies made within the UMA in an effort to determine the best approach for obtaining additional water for both individual communities and proposed regional systems. These studies have revealed that ample amounts of fresh (ground or surface) and sea water are available within the immediate vicinity to satisfy the future UMA water supply requirements. However, no final determination of feasibility or practicality can be made without in-depth study.

Surface

A plan for southeastern Connecticut, an area much larger than the UMA of this study, evaluated thirty-seven surface reservoirs that were considered potential future water sources for southeastern Connecticut. Those sites judged capable of enhancing the water supply situation of the UMA are shown on Figure 23. The needs of the UMA can be satisfied by any of several combinations of these sources.

Although the present study does not recommend a particular course of action, it is recognized that much effort went into the 1970 Water Supply Plan of the SCWA. Therefore, the plan will be summarized, to the extent that it applies to the UMA.

Phase 1 - Shewville Brook - Joe Clark Reservoir.

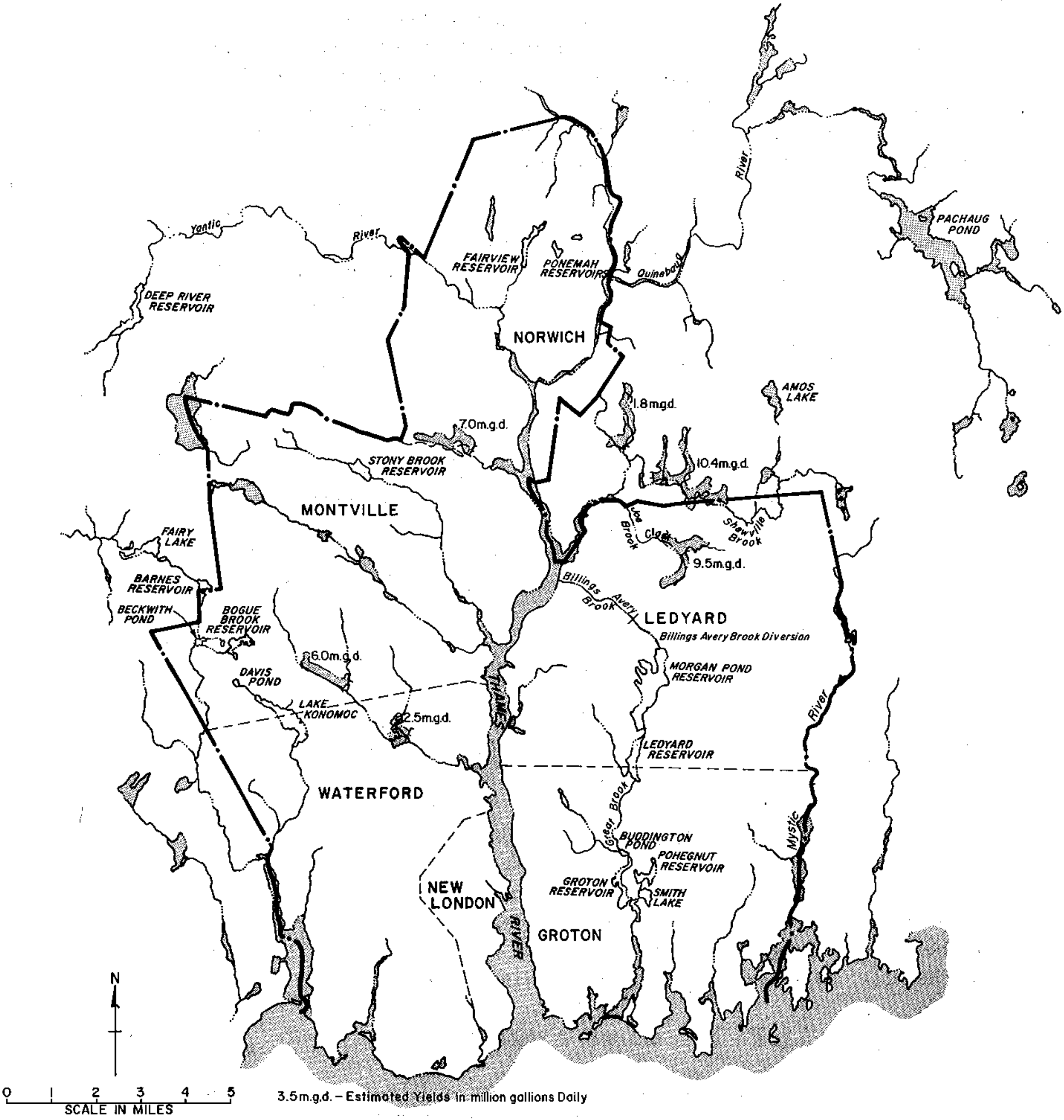
Part of the flow of Shewville Brook would be filtered and conveyed to the New London-Waterford system. The remainder of the water withdrawn would be used to augment natural flow into a new reservoir on Joe Clark Brook. This would increase the yield of the Great Brook supply of the City of Groton. Utilization of Shewville Brook in combination with the Joe Clark Brook Reservoir would provide a dependable yield of approximately 9.5 mgd.

Phase 2 - Broad Brook Reservoir.

The construction of a reservoir on Broad Brook just east of Parks Road in Preston would supply water that would be diverted into Shewville Brook, increasing the yield of the Shewville-Clark system by 10.5 mgd. Water from the reservoir would be conveyed by gravity (partly by trench and partly by pipeline) between the dam and Amos Lake, below Preston City. This water would then flow from Amos Lake by trench and streambed southerly into Avery Pond, located northeast of the interconnections of State Routes 2 and 164. Avery Pond discharges into a tributary of Shewville Brook.

Phase 3 - Pachaug River Diversion.

A diversion is planned from Pachaug River out of Pachaug Pond. The Pond is located in Griswold and lies about one mile northeast of the edge of the Broad Brook drainage area. By means of a pumping station and transmission main, discharge of water would be effected from the pond into Rattlesnake Brook, a tributary of Broad Brook, and then into Broad Brook Reservoir. This phase would provide an additional 7.5 mgd to the project.




**POTENTIAL WATER SOURCES**
**NEW LONDON - GROTON - NORWICH UMA**

**FIGURE 23**

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The total increased capacity of the supply, achieved by this series of projects, would be 27.5 mgd, thus precluding the 2020 UMA deficit. Moreover, the project, as illustrated on Figure 24, would lend itself to further expansion if the need should ever arise.

### Ground Water

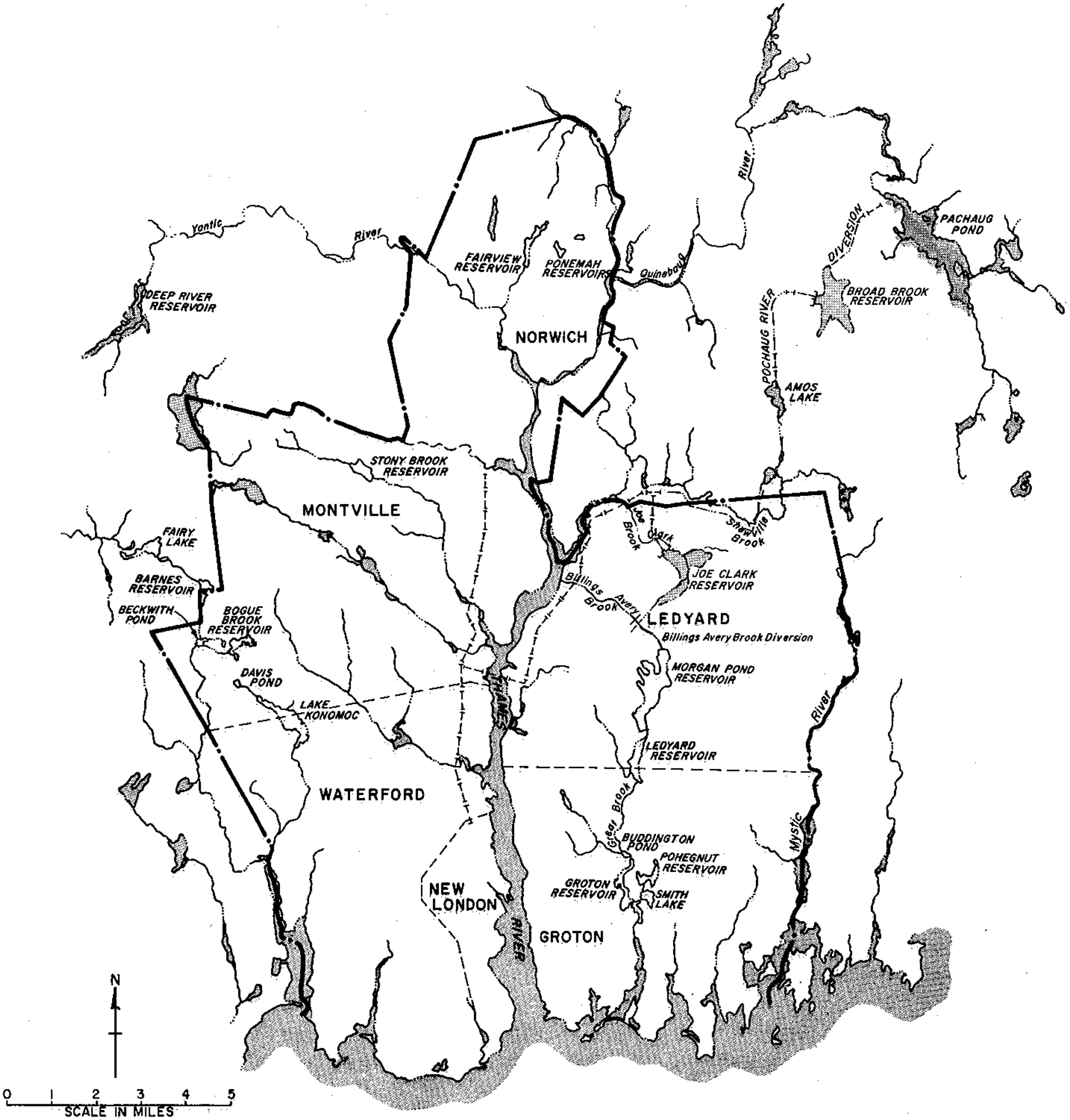
While surface water can be estimated with a reasonable degree of accuracy, ground water is not so readily determined. According to the USGS and Connecticut Water Resources Commission Study of 1966-68, the aquifers underlying areas entirely within the UMA may potentially yield 52.0 mgd. While this figure is not conclusive, it is an indication that more than twice the water needed to satisfy the 2020 deficit may be available from wells. Nothing, however, short of actual well construction and extended operation can give an authoritative answer to questions concerning the quantity or quality of water from any particular aquifer. In the case of the New London-Groton-Norwich Urban Metropolitan Area, test wells must be dug and proper analysis performed before any protracted decision concerning ground water can be made.

Although the geologic opportunity in the UMA appears suitable for yielding substantial amounts of ground water, only individual private development has occurred to date. Ground water development, extensive enough to meet urban needs, has not been considered economically feasible by local planners, because of the existence of ample surface sources already developed in the area.

### Tidal Dam

The possibility for construction of a tidal dam across the Thames River was investigated in 1962 by Metcalf & Eddy, consultants for the Eastern Connecticut Industrial Fresh Water Development Commission.

Their plan for the construction took into consideration water supply, navigation, and other factors relevant to the problems of the area. The cost for such a project, according to figures adjusted to 1971 values, would be about $17,400,000 to provide approximately 140 mgd for water supply, not including treatment, pumping, and distribution. Recent findings, however, have indicated that conditions possibly detrimental to the environment might result if such a plan were to be effected.




* Plan of the Southeastern Connecticut Regional Planning Agency and Southeastern Connecticut Water Authority.

**WATER SUPPLY PLAN**
**NEW LONDON - GROTON - NORWICH UMA**
**FIGURE 24**

Anderson-Nichols & Co. Inc.

### Desalting

Desalting offers an opportunity for this UMA that should be considered seriously. The 2000 deficit of 6 mgd is that of many presently operating desalting package plants. The prospects for lowering the cost of producing potable water by desalting over the next 15 to 20 years are good. Disposal of desalting wastes is a major factor, but probably will not always be an unsurmountable drawback. Should such a plant be tried and proved for the area, phased additions might be considered to meet 2020 deficits.

## CONCLUSIONS

Apparent deficits for the UMA of 7.1 and 23.1 mgd are projected for the benchmark years 2000 and 2020, respectively. However, cooperative plans by the Southeastern Connecticut Regional Planning Agency and the Southeastern Connecticut Water Authority for surface impoundments to supplement existing surface water development, appear ample to preclude these deficits. Ground water, desalting, and a tidal dam are other alternatives available, as well as combinations of surface water impoundments not presently included in the regional plan. Although three major utilities provide water to more than 95 percent of that UMA population now served, the fact that 37 minor utilities exist suggests the possible need for mass interconnections and consolidations with the major utilities, to meet the urban expansion anticipated. Certainly, a need exists to upgrade both quality and service of many of these utilities.

Regionalization has already been effected, through the establishment of a planning agency and simple management authority. Obviously, treatment and transmission capacity must be planned and constructed to keep pace with the need to nearly double present source capacity during the next fifty years.

(During the course of review of the draft of this study, comment was received that the status of the Southeastern Connecticut Water Authority is under review. The outcome of that review, however, does not invalidate the general approach toward regionalized water supply reflected herein.)

# CHAPTER 9. HARTFORD

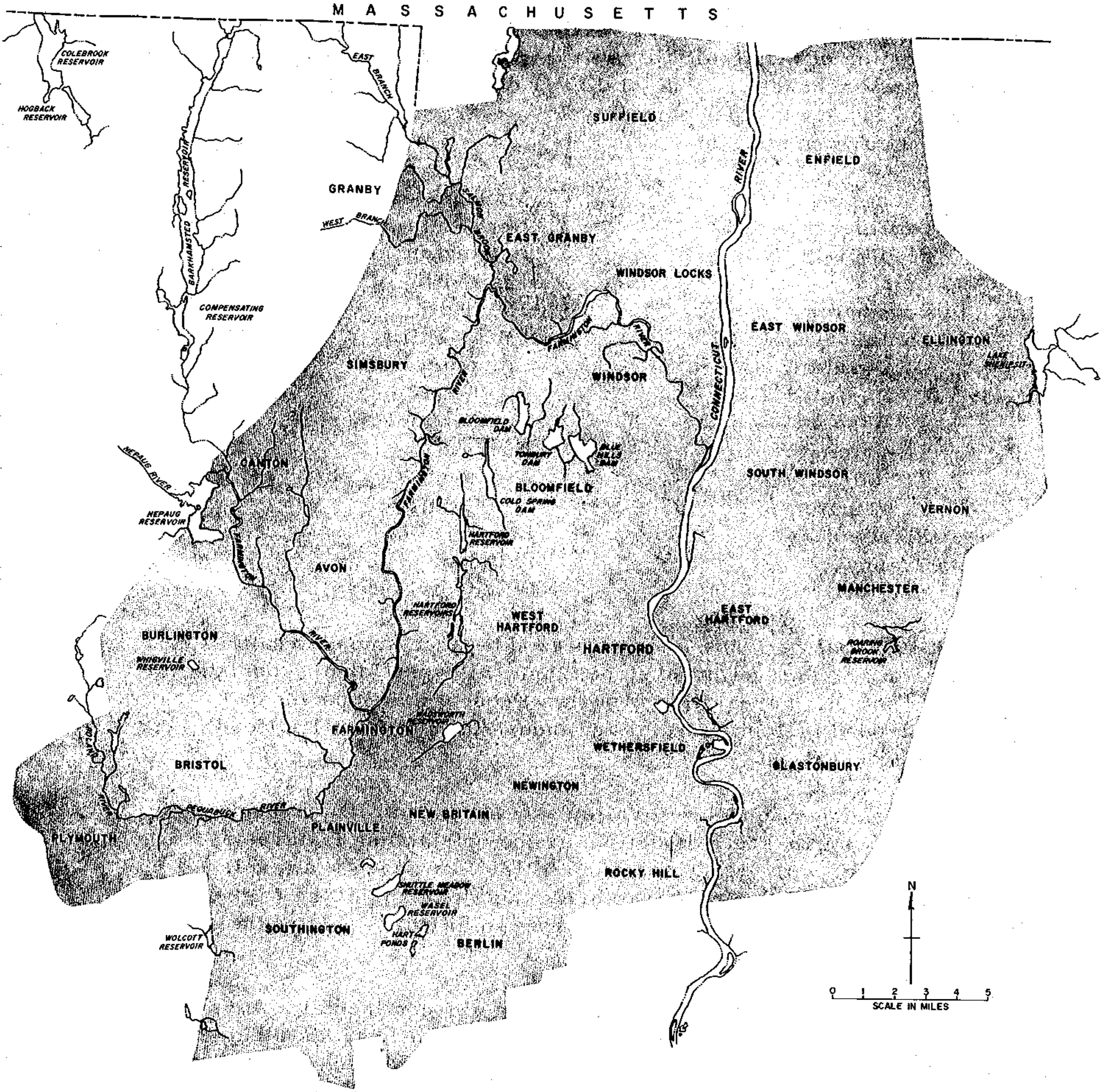
The Hartford Urban Metropolitan Area is located in the central portion of the State of Connecticut, and is bounded on the north by Massachusetts. The total area of the UMA, delineated on Figure 25, covers approximately 700 square miles, and its components are numerous:

| | |
|---|---|
| Avon | Manchester |
| Berlin | New Britain |
| Bloomfield | Newington |
| Bristol | Plainville |
| Burlington | Plymouth |
| Canton | Rocky Hill |
| E. Granby | Simsbury |
| E. Hartford | Southington |
| E. Windsor | South Windsor |
| Ellington | Suffield |
| Enfield | Vernon |
| Farmington | W. Hartford |
| Glastonbury | Wethersfield |
| Granby | Windsor |
| Hartford | Windsor Locks |

Current land-use patterns indicate a good balance among urban, agricultural, and as yet undeveloped land, allowing for appropriate and well controlled area-wide growth. Present development is oriented around the commercial and industrial center of Hartford, capital of Connecticut.

The Connecticut River Valley extending centrally through the UMA in a north-south direction, is the outstanding feature of the topography, with elevations of up to 130 feet above sea level. Summits of about 900 feet characterize the highlands to the east and west, while broad valleys and scattered hills are part of the lowlands to the south.

The climate of the area is classified as continental. Average precipitation for the UMA approximates 44 inches, distributed uniformly throughout the year; snowfall averages 60 inches. The mean temperature is about 46°F, with extreme normal daily averages of 25°F and 70°F occurring in January and July, respectively. Mean relative humidity is about 70 percent. Prevailing




**HARTFORD UMA**

**FIGURE 25**

winds are generally from the south.

The UMA contains an excellent network of highways, and is well serviced by rail and air. Its location is approximately 90 miles from either New York or Boston.

Hartford is a port of entry, standing at the head of navigation on the Connecticut River. It is the focal point of a growing metropolitan area, united socially and economically, but fragmented politically by the more than 30 local governments within its sphere of influence. Professional services, finance, and retail trade constitute a large part of the overall economy of Hartford - the city is the principal retail market for more than half the state, as well as the home of more than 25 insurance companies and many large banking institutions. The manufacture of internationally-known products, however, accounts for an even greater portion of the economy. The leading industries in Hartford are those of non-electrical machinery, transportation equipment excluding motor vehicles, and textiles, while the chief manufactured product is aircraft engines. Other goods produced include brushes, firearms, hardware, ball bearings, clocks, automobile parts, and plastics. Thus, Hartford thrives on a balance of business and industry.

Approximately one-half of the builders' hardware manufactured in the state of Connecticut is produced in New Britain, the "Hardware City". Formerly known as the "Great Swamp," New Britain is now a center of various industries that produce such other goods as locks, saddlery, ball bearings, tools, and automated machinery. The city of Bristol is located on the Pequabuck River and has been predominately a manufacturing center since colonial days. Clocks, watches, brass products, springs, ball bearings, electronic devices, and bicycle and automobile parts are produced here.

## POPULATION

The population of the UMA is growing moderately, with an increase of almost 20 percent between 1960 and 1970. Hartford has lost population steadily since 1930, even though it is the economic and social core of the region; but the remaining 29 towns of the UMA have experienced growth. Because of its proximity to other urban centers, agreeable climate, transportation network, and abundance of buildable land, the UMA should continue to attract new industry and residents. Population projections indicate that the Hartford UMA will increase in population from about 850,900 in 1970 to more than 1,386,600 by the year 2020, an increase of approximately 63 percent.

Population data are presented in Table 29.

TABLE 29

POPULATION DATA

HARTFORD UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 713.9 | 850.9 | 984.5 | 1,241.9 | 1,386.6 |
| Population per square mile | 1,020 | 1,215 | 1,405 | 1,775 | 1,980 |

## WATER USAGE

Available data indicate that approximately 712,000 people and 350 industries received nearly 84 mgd from 53 large and small water supply systems during the mid 1960's. Domestic usage at that time approximated 54 mgd, but is expected to increase to 143 mgd by the year 2020. Industrial water usage, estimated to be about 80 mgd in the mid 1960's is expected to increase to 162 mgd. While only about 38 percent of the industrial demand has been provided by public systems, it is believed that industries will purchase larger percentages of water from public utilities in the future. Data pertinent to water usage are presented in Table 30, and shown graphically on Figure 26.

## KNOWN WATER SUPPLIES

### Summary

The thirty cities and towns that compose the Hartford UMA are presently supplied by a total of 53 water-supply systems;

TABLE 30

WATER USAGE
(in mgd)

HARTFORD UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 54 | 83 | 121 | 153 |
| Publicly-supplied industrial | 30 | 35 | 50 | 75 |
| TOTAL M & I | 84 | 118 | 171 | 228 |
| Publicly-supplied industrial | 30 | 35 | 50 | 75 |
| Self-supplied industrial | 50 | 55 | 62 | 76 |
| TOTAL INDUSTRIAL | 80 | 90 | 112 | 151 |
| Water Use (gcd) (Based on M & I) | 118 | 120 | 138 | 164 |

POPULATION AND M&I WATER USE
HARTFORD UMA

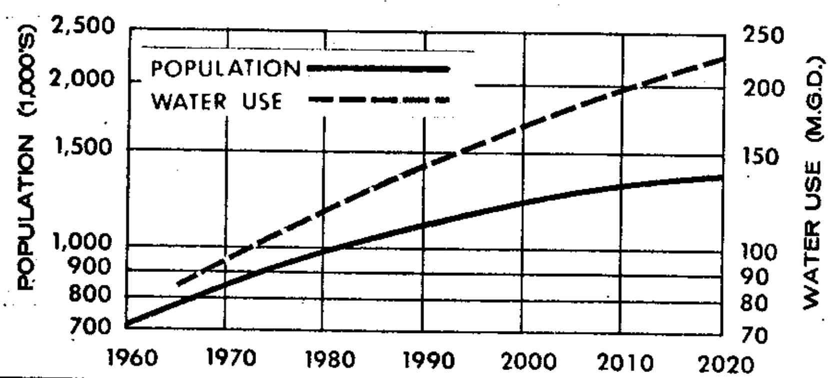
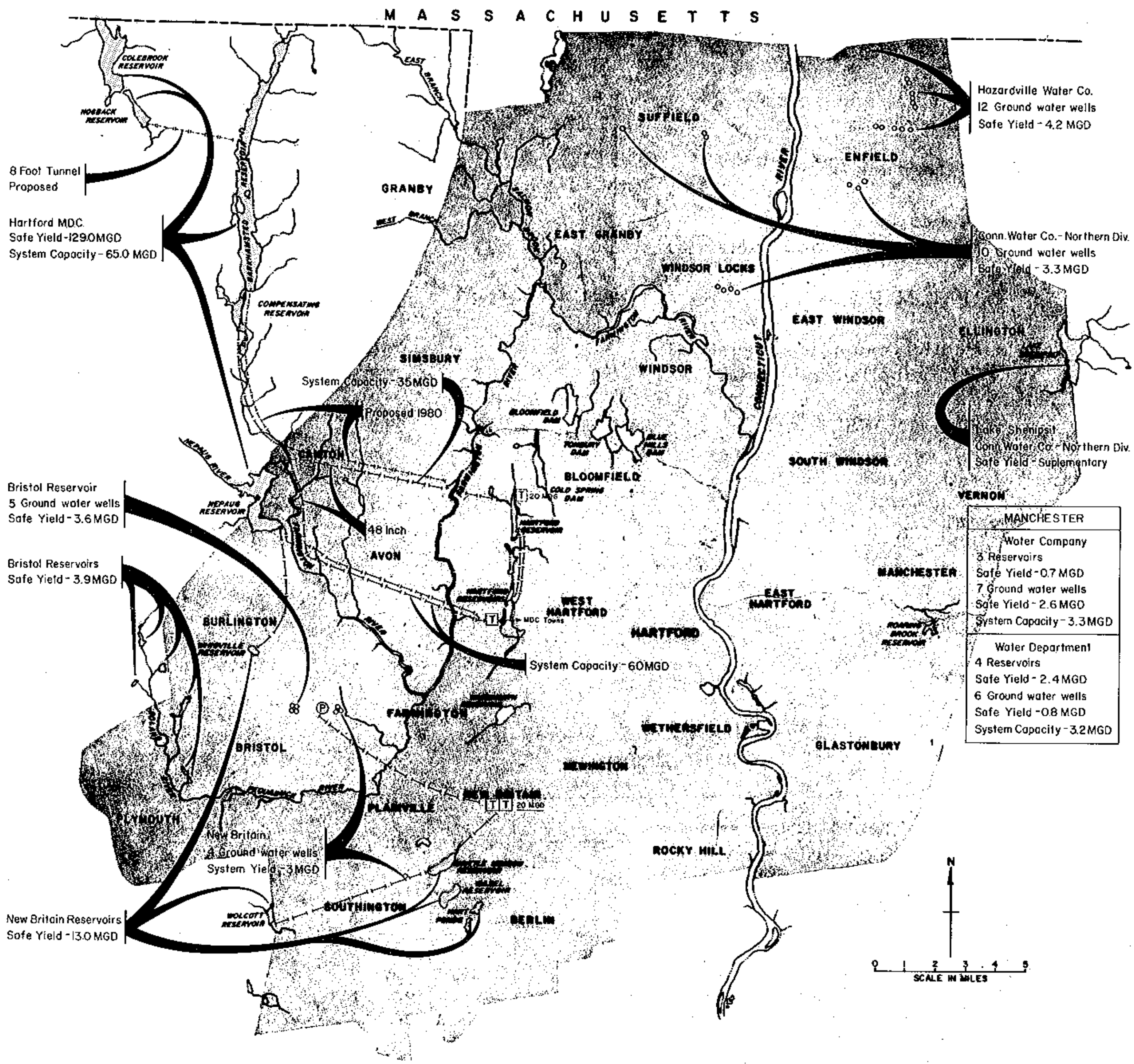



FIGURE 26




# KNOWN WATER SUPPLIES HARTFORD UMA

**FIGURE 27**

Anderson-Nichols & Co., Inc.

seven are municipally owned, two are owned by the state, and 44 belong to private owners or investors. Collectively, the systems obtain water from 31 surface reservoirs, with a safe yield, available for water supply, of 146.1 mgd; and from more than 130 wells having an estimated yield of 33.1 mgd. While the 179.2 mgd from these two sources have been developed for water supply, only 122.6 mgd are presently available, because of treatment, transmission, and allocation limitations.

Of the 53 water supply systems, nine serve more than 10,000 people each, and so are considered major utilities. Data pertinent to these are presented in Table 31.

TABLE 31

KNOWN WATER SUPPLIES

HARTFORD UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Hartford Metropolitan District Commission | 373,000 | 49.1 | Reservoir | Barkhamsted | 55.0 | 65.0 | 95.0 | 65.0 |
| | | | Reservoir | Nepaug | 27.0 | | | |
| | | | Reservoir | Hogback and Colebrook River | 47.0 | | | |
| New Britan Water Department | 100,500 | 11.2 | Surface | 6 Reservoirs | 13.0 | 20.0 | N/A | 16.0 |
| | | | Ground | 4 Wells | 3.0 | | | |
| Conn. Water Co. - Northern Division | 40,000 | 4.0 | Ground | 10 Wells | 3.3 | | 1.8 | 5.1 |
| | | | Surface | Lake Shenipsit | Supplementary | | | |
| Bristol Water Dept. | 38,500 | 5.0 | Surface | 6 Reservoirs | 3.9 | 5.0 | N/A | 7.5 |
| | | | Ground | 5 Wells | 3.6 | | | |
| Manchester Water Dept. | 27,300 | 3.0 | Surface | 4 Reservoirs | 2.4 | | | 3.2 |
| | | | Ground | 6 Wells | 0.8 | | | |
| Southington Water Works | 18,750 | 2.0 | Surface | 3 Reservoirs | 0.4 | N/A | 2.0 | 2.0 |
| | | | Ground | 4 Wells | 3.2 | | | |
| Manchester Water Co. | 14,000 | 1.2 | Surface | 3 Reservoirs | 0.7 | N/A | N/A | 3.3 |
| | | | Ground | 7 Wells | 2.6 | | | |
| Hazardville Water Co. | 14,250 | 1.0 | Ground | 12 Wells | 4.2 | N/A | N/A | 4.2 |
| Plainville Water Co. | 12,600 | 1.1 | Surface | 1 Reservoir | -- | 0.4 | N/A | 2.8 |
| | | | Ground | 3 Wells | 2.4 | | | |
| Minor Systems (44) | 70,600 | 5.4 | Surface | 5 Reservoirs | 8.0 | N/A | -- | N/A |
| | | | Ground | 95 Wells | 10.0 | | | |

Hartford and 14 surrounding towns are served by the Hartford Metropolitan District Commission (MDC), a large regional system with the physical source potential to supply nearly the entire UMA. As shown on Figure 27, the Barkhamsted and Nepaug Reservoirs, located on the Farmington River and Nepaug River (Farmington River tributary), respectively, are currently being used by the MDC as sources of water supply, while the West Branch (Hogback) Reservoir, on the west branch of the Farmington River, is used to regulate stream flow. The recently completed Colebrook River Dam and Reservoir, a multi-purpose installation located upstream of Hogback Reservoir, has increased the water storage available to the MDC by 10 billion gallons. The Colebrook and Hogback Reservoirs are in tandem and at present serve two major purposes: regulation of stream flows (riparian committments), and flood protection.

The four reservoirs combined provide a safe yield of 129 mgd to the MDC, of which 82 mgd is presently available, with transmission capacity as the limiting factor. The network of pipelines and tunnels from the Nepaug and Barkhamsted Reservoirs has a present capacity of about 95 mgd. More pipelines, and a tunnel from Hogback to Barkhamsted Reservoir will make the additional yield of the West Branch and Colebrook Reservoirs available to the MDC for water supply, as indicated on Figure 27. In emergency, New Britain is authorized to draw up to 10 mgd from the MDC's Nepaug Reservoir.

The major treatment facility currently serving the UMA is operated by the MDC in West Hartford. It has an annual average capacity of 45 mgd, and 62.5 mgd peak day is of the "slow sand" filtration type. Chlorination, fluoridation, and corrosion control are provided.

A second MDC purification plant is presently being completed in Bloomfield. Using the "rapid sand" filtration process, it will meet the same treatment standards as the West Hartford plant. The facility will have an initial annual average capacity of 20 mgd, (30 mgd peak day) and an ultimate annual average capacity of 80 mgd, when all phases of construction are completed.

Future Adequacy

The total safe yield of water supply sources available to the systems in the Hartford UMA is about 190 mgd, of which, however, only 122.6 mgd are presently available, because of treatment and transmission facilities limitations. Projects scheduled for construction within the next few years, such as the tunnel from Hogback to Barkhamsted Reservoir, the MDC treatment plant in Bloomfield, and treatment facilities in New Britain will increase the nominal aggregate capacity to about 177 mgd. When this figure is compared with projected water demands, as in Table 32, a deficit in water supply capability does not appear until shortly after the year 2000. It is important to note, however, that the water deficit analysis involves 53 utilities, with many not interconnected at present. The composite deficit for the UMA is misleading, therefore, since a local deficit could occur sooner, unless preventive action is planned and implemented. For example, the Northern Connecticut Water Company is already experiencing a problem in meeting its peak demands. On the other hand, areas such as the present Hartford MDC service region should experience no water shortage within the next 50 years.

The major future water supply problem for the Hartford UMA exists in the location and development of sources. From Table 32, it is evident that additional sources yielding at least 51 mgd must be developed prior to 2020. As sources of supply are developed, transmission and treatment facilities must be constructed to accomodate the purification and transportation of water to the customers within the UMA. Future transmission and treatment requirements will be on the same order of magnitude as source needs.

Facilities presently under construction will add approximately 54 mgd by 1980. Recent information received from the Board of Water Commissioners of New Britain indicates that decreases owing to age, breakdown and inefficiency in the older plant are offset only by the new plant. Because sedimentation basins were not enlarged, the detention time still controls the capacity of the plant. Correction of this deficiency has been assumed here, and the full increase in capacity used to calculate the deficit.

TABLE 32

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

HARTFORD UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 84.0 | 118.0 | 171.0 | 228.0 |
| Present Capability (mgd) | 122.6 | 177.0 | 177.0 | 177.0 |
| Deficit | -- | -- | -- | 51.0 |

## DESIRABILITY FOR REGIONALIZATION

The need for regionalized planning is already well recognized in the Hartford UMA, because every community is an active member of either the Capitol Region Planning Agency, Hartford, or the Central Connecticut Planning Region, Plainville. Though the functions of these planning agencies are many, their basic powers are limited to studies and recommendations to guide the growth and development of the region, through inter-community cooperation and farsighted planning.

Nearly 95 percent of the public water needs of the Hartford UMA, one of the largest regions in the NEWS Study, are met by the nine major utilities. They supply all or parts of 25 communities, while the remaining 44 systems generally serve only portions of communities, such as villages, housing developments, and trailer parks.

The actual physical interconnection of all 53 existing water supply systems in the UMA would be impractical; but expansion of the MDC, and interconnection with several of the other major utilities, appears to be desirable as well as inevitable. Furthermore, from an economic and engineering viewpoint, expansion and interconnection are feasible. For example: The MDC system is authorized to provide water to towns through which its transmission mains pass; the system is already interconnected with the Northern Connecticut Water Company for emergency purposes, and provides water to several non-member towns on a wholesale basis. In toto, the MDC could supply 24 of the 30 towns in the UMA, either out of convenience, or in compensation for transmission main right-of-way.

On the other hand, the Hartford UMA is rich in water resources, as reflected by the large number of wells shown in Table 31. Ground water is readily available and several possible reservoir sites are under consideration. Consequently, as future demographic and industrial growth dictates expansion of the existing systems, and/or the development of new systems, the water-supply situation in the Hartford UMA will probably be much the same as that of the greater Boston area. Within the physical bounds of Boston's Metropolitan District Commission water supply service area, several towns are either maintaining independent systems, or receiving water under contract with the Commission to supplement their own systems.

Considering the availability of ground and surface water within the boundaries of the Hartford UMA, it seems unlikely that regionalization, to the degree of total physical integration, will be either necessary or desirable within the time frame of this study.

## DEVELOPMENT ALTERNATIVES

### Ground Water

Most of the water supply systems serving municipalities in the Hartford UMA are either wholly or partially dependent upon ground water; wells yielding a total of nearly 35 mgd are presently in operation. The total dependable yield of all aquifers located rather uniformly throughout the UMA is estimated as 250 mgd. Of this amount, approximately 80 to 85 mgd could be provided by several large wells. Wells would most probably be used to meet industrial and rural needs, and to be a part of the expansion of water companies presently utilizing ground water as sources.

The cost of well development in the past, though quite variable, has averaged about $100 thousand per one mgd, not including transmission expenses. Costs vary according to individual aquifer yield, ease and method of construction, and numerous other factors. If an additional 50 mgd were provided in the future from wells in the Hartford area, total source development costs would be approximately $5 million.

Development of ground water, either on a regional or local basis, would offer several advantages: ground water development is amenable to phased construction; the quality of water, obtained in the past from wells in the area, has demonstrated little need for treatment; and transmission costs are minimal, since ground water sources are in close proximity to the demand centers.

One should note, however, that ground water is susceptible to many problems: excessive mineral content; contamination from surface sources; depletion over local or expansive areas because of excessive drawdown; and fluctuation during drought periods. The alternative of ground water development, therefore, must be studied carefully before deciding to proceed.

Surface Reservoirs

Several reservoir sites have been investigated by consultants to the Capitol and Central Connecticut Region Planning Agencies. The sites and their reported safe yields follow.

| Site | Safe Yield |
|---|---|
| Blackledge River | 6.5 |
| Dickinson Creek | 5.0 |
| East Branch Salmon Brook | 6.0 |
| Fawn Brook | 7.0 |
| Hop River | 5.5 |
| Rock Brook - Cook Dam (diversions from E. Branch Rock Brook and Leadmine Brook to Cook Reservoir) | 4.5 |
| Skungamaug River | 6.8 |
| Thrasher Brook | 2.9 |
| West Branch Salmon Brook | 10.0 |
| Total | 54.2 |

Total development costs for the above reservoirs, including necessary treatment facilities, but not including transmission mains, would be about $48 million - ten times the cost for ground water per mgd.

Connecticut River

The Connecticut River has been suggested as a possible source of water by the Consultant to the Capitol Region Planning Agency. Cost estimates for the construction of a 50 mgd treatment facility to be located below the confluence of the Connecticut and Farmington Rivers, have been stated at approximately $10 million - a figure which does not include transmission costs.

The Connecticut, with an average flow of 10.5 bgd at Thompsonville, is one of the largest rivers in the Northeastern United States: it has a drainage area of 9,661 square miles in New Hampshire, Vermont, Massachusetts, and Connecticut (above Thompsonville). During the drought of the 1960's, the average summer flow dropped to about 2,650 mgd, and reached a minimum of 626 on 20 October 1963. In the recent Connecticut

River Basin Coordinating Committee Report, "Comprehensive Water and Related Land Resources Investigation, Connecticut River Basin," low-flow releases of 0.2 csm is recommended which, at Thompsonville, would amount to about 1230 mgd.

The river has served as a dependable source of supply for several industries throughout the Connecticut River Basin, but the main stem is not used as a source of municipal water supply. The quality of the Connecticut River in the Hartford vicinity is very poor; but as conditions change, and pollution control enhances water quality, use of the Connecticut River as a municipal water supply source may become feasible.

## CONCLUSIONS

While the main core of the UMA, served by the Hartford Metropolitan District Commission, appears to be well prepared to meet the expected water demands for many years, several of the smaller municipal and private water supply systems are already experiencing difficulty in supplying their own needs.

Although regional area planning has been in effect for several years, physically integrated water supply for the entire UMA does not appear to be a necessity, because both ground and surface water resources are abundant throughout the area. However, some interconnection of major systems seems warranted. Enlargement of the sedimentation basins in New Britain must also be accomplished to assure that added new treatment plant capacity may be fully utilized.

Future water resource development will entail a combination of well drilling and upland impoundments, with a treatment plant on the Connecticut River as a long-range possibility. A total of about 51 mgd additional supply is indicated prior to the year 2020, to be provided from that combination of sources that will best suit area needs. Consideration should also be given to the acquisition or preservation of potential reservoir and ground water sites, to insure future water availability.

## CHAPTER 10. ALBANY-SCHENECTADY-TROY

The Albany-Schenectady-Troy Urban Metropolitan Area, located in the east central portion of New York State, covers approximately 850 square miles of land area. It is named for the three core cities which are situated along the Mohawk and Hudson Rivers. The UMA that is expected to evolve by the year 2020 consists of the "tri-cities" and those smaller communities contiguous to them. The area is depicted on Figure 28; the components expected to be included in it, in whole or in part, follow.

Albany County

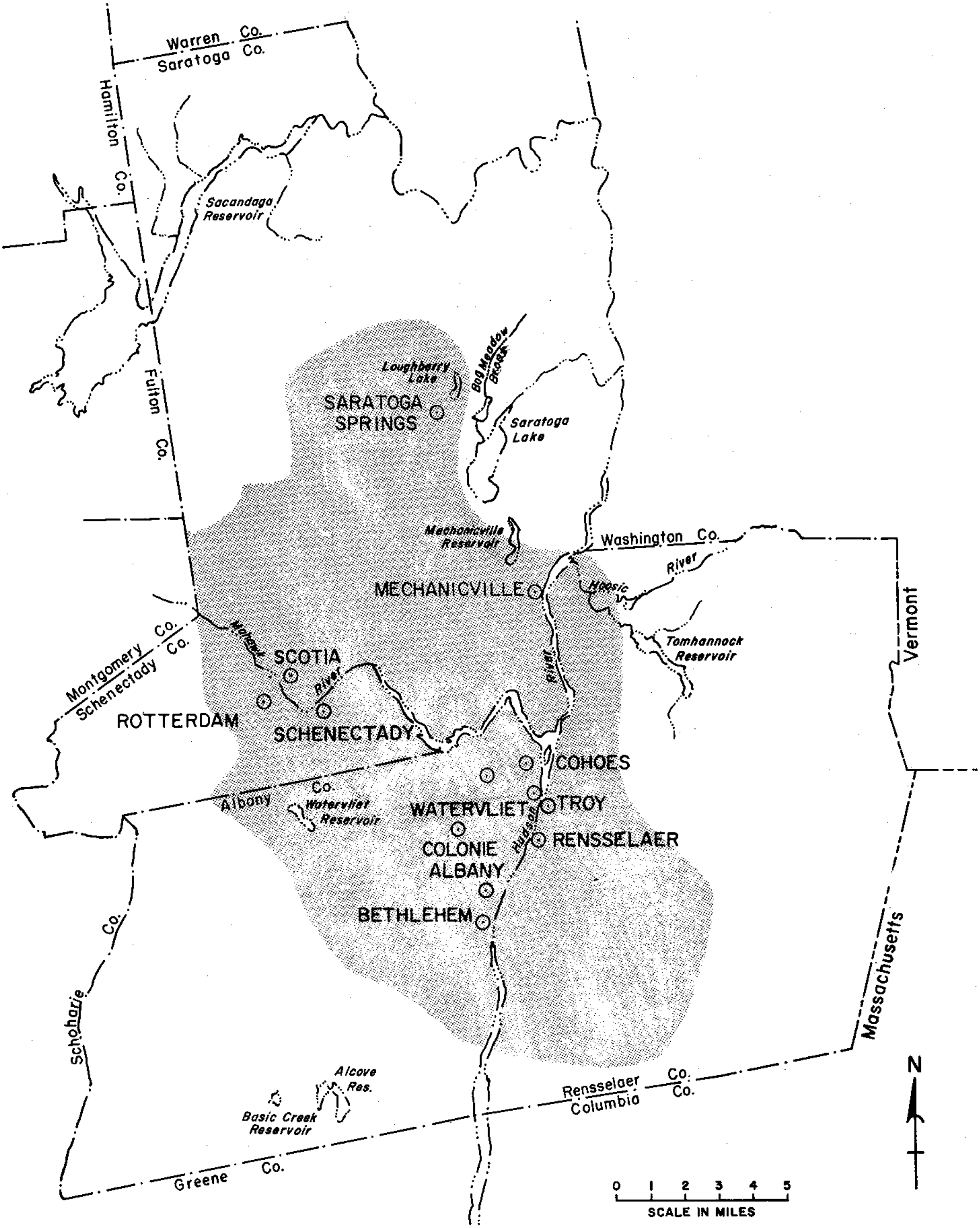
Albany city
Bethlehem town
Cohoes city
Colonie town
  Colonie village
  Latham (u)
  Loudonville (u)
  Menands village
  Roessleville (u) (part)
Green Island town
  Green Island village
Guilderland town
  Altamont village
  Roessleville (u) (part)
  Westmere (u)
Knox town (part)
New Scotland town (part)
  Voorheesville village
Watervliet city

Rensselaer County

Brunswich town (part)
East Greenbush town
Hampton Manor
Nassau town (part)
  Nassau village (part)
North Greenbush town
Poestenkill town (part)
Rensselaer city
Sand Lake town (part)
  Averill Park (u)
  West Sand Lake (u)
Schaghticoke town (part)
  Schaghticoke village
  Valley Falls village (part)
Schodack town (part)
  Castleton-on-Hudson village
  Nassau village (part)
Troy city

Saratoga County

Ballston town (part)
  Ballston Spa village (part)
Charlton town (part)
Clifton Park town
  Clifton Knolls (u)
  County Knolls (u)
Galway town (part)
  Galway village
Greenfield town (part)
Halfmoon town
  Halfmoon Junction (u)
Malta town
  Round Lake village
Mechanicville city
Milton town
  Ballston Spa village (part)
  Milton (u) (part)
  North Ballston Spa (u)
Saratoga Springs city




**ALBANY-SCHENECTADY-TROY UMA**

Anderson-Nichols & Co. Inc.

**FIGURE 28**

Saratoga County (con't)

Stillwater town (part)
  Stillwater village
Waterford town
  Waterford village
Wilton town (part)

Schenectady County

Glenville town
  Scotia village
Niskayuna town
  Niskayuna (u)
Rotterdam town (part)
  Rotterdam (u)
Schenectady city

(u) - unincorporated

The topography of the UMA is varied: steep river plains of up to 500 feet border the Hudson and Mohawk Rivers, while gently rolling hills dot the area beyond the plains. Remaining evidence of the existence of pre-glacial Lake Albany is in the form of the Heldenberg Escarpment, which forms the southwestern border of the UMA. East of the escarpment lie Albany, Schenectady and Troy, in what was once the bottom of the lake.

The areas's climate is classified as humid-continental. Average precipitation for the UMA is approximately 43 inches, distributed fairly uniformly throughout the year; annual runoff averages about 22 inches. The mean temperature at Albany Airport is about 45°F, with daily averages of 25°F and 67°F occurring in January and July, respectively. Mean relative humidity is about 70 percent.

Adequate air and rail transportation facilities provide connections to other urban centers in the Northeast, thus accommodating the area's industrial and passenger needs. The Hudson River is capable of supporting large transport vessels, and so forms an economic link between Albany and New York City. A similar function is performed between Cohoes and the Great Lakes region by the Mohawk River and New York State Barge Canal.

The region's economy depends strongly on the city of Albany, capital of New York. Industrial development in the tri-city area has established the UMA as the economic center of northeastern New York State. Its location along the Hudson and Mohawk Rivers has traditionally attracted large water-using industries, such as paper and textile mills, and primary metals processors. Because of the demand for land for residential development, the number of farms within the area has been declining continually. Therefore, agriculture is a small industry, limited primarily to the production of dairy goods.

## POPULATION

The principal population centers include the three core cities, and the communities in close proximity to them. The combined population of Albany-Schenectady and Troy, according to the 1970 census, amounted to more than 38 percent of the overall UMA population. However, the three cities have been experiencing a steady decline in population since 1950, as more and more people move from them to the nearby suburban areas. The result is a healthy growth rate, during the 1960-1970 decade, for most of the surrounding towns and villages within the UMA. In fact, some communities more than doubled in population during that time. The overall gain in population of the entire UMA was about 51,000, or an increase of over 8 percent.

Population projections indicate that the UMA population will increase by almost 75 percent during the study period. Projected UMA population and density figures are shown in Table 33.

TABLE 33

POPULATION DATA

ALBANY-SCHENECTADY-TROY UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 607.9 | 659.6 | 743.6 | 971.1 | 1,150.6 |
| Population per square mile | 715 | 775 | 875 | 1140 | 1355 |

## WATER USAGE

Available data indicate that in the mid 1960's, about 614,000 people were served by large and small water supply

TABLE 34

WATER USAGE

ALBANY-SCHENECTADY-TROY UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 70.0 | 99.8 | 144.3 | 188.8 |
| Publicly-supplied industrial | 23.0 | 24.2 | 39.0 | 61.0 |
| TOTAL M & I | 93.0 | 124.0 | 183.3 | 249.8 |
| Publicly-supplied industrial | 23.0 | 24.2 | 39.0 | 61.0 |
| Self-supplied industrial | 117.0 | 117.0 | 117.0 | 117.0 |
| TOTAL INDUSTRIAL | 140.0 | 141.2 | 156.0 | 178.0 |
| Water Use (gcd) (Based on M & I) | 151.5 | 166.8 | 188.8 | 217.1 |

POPULATION AND M&I WATER USE

ALBANY-SCHENECTADY-TROY UMA

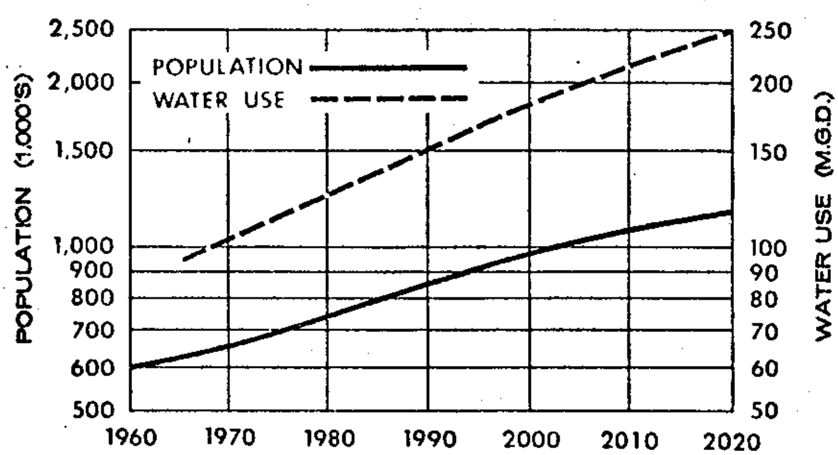
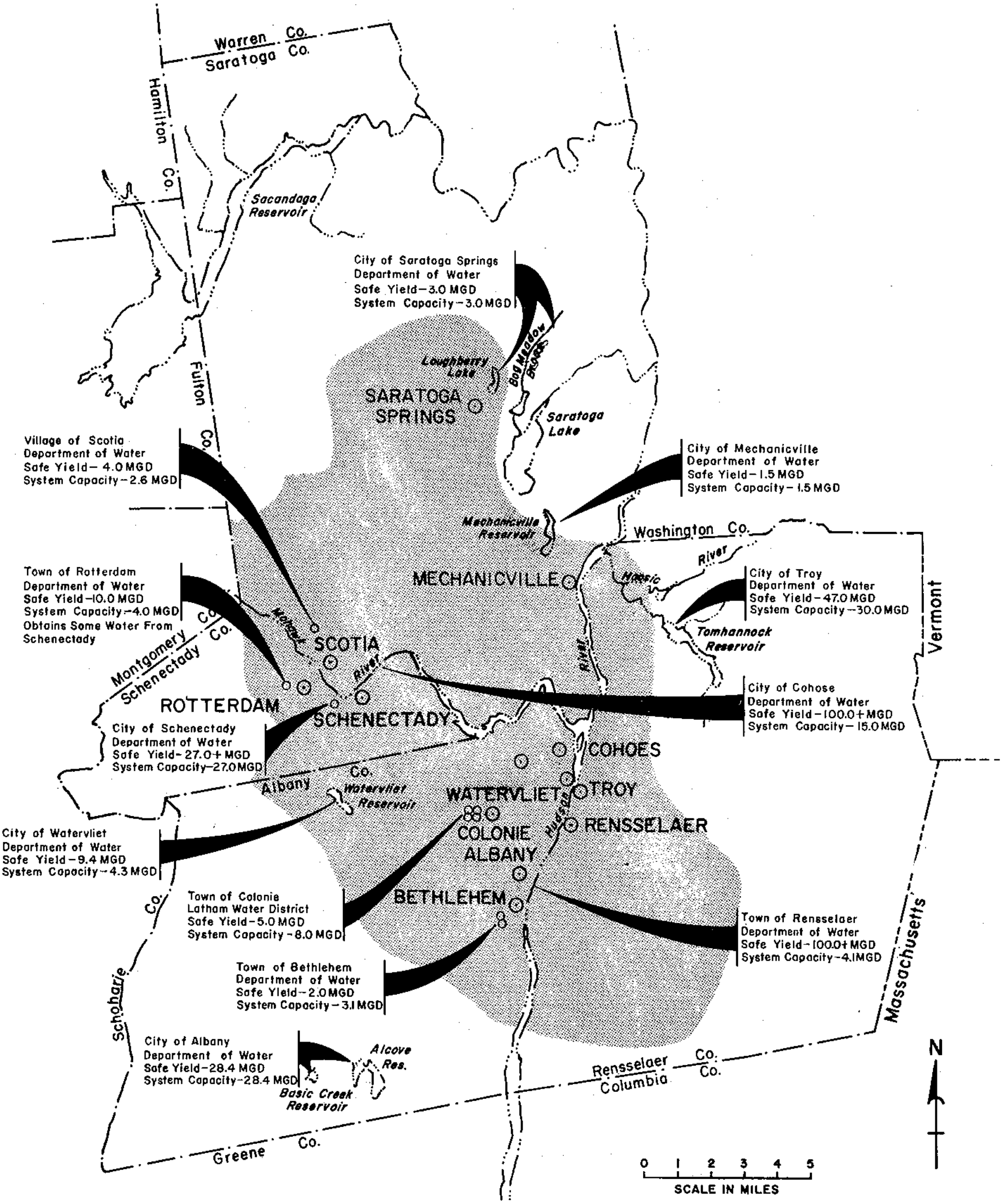



FIGURE 29




**KNOWN WATER SUPPLIES**
**ALBANY-SCHENECTADY-TROY UMA**



Anderson-Nichols & Co. Inc.

**FIGURE 30**

systems throughout the UMA, while another 7,750 people obtained their supply from individual sources. The average publicly-supplied M & I demand was about 93 mgd.

The water requirements will obviously increase with the growth in population. It is expected that by the year 2020, the UMA will require about 250 mgd to satisfy its M & I water requirement - an increase of more than 165 percent over present demand.

The projections for water usage are shown in Table 34, and Figure 29 illustrates graphically the population projections and M & I water demands for the UMA.

## KNOWN WATER SUPPLIES

### Summary

Twenty-eight private and municipal utilities, not including individual water supply systems, operate within the UMA. Twelve of these are considered major supply systems, generally serving over 10,000 people with a demand for 1.0 or more mgd. The remaining smaller utilities serve local concentrations of communities or individuals from ground water or surface sources, with yields adequate to meet the present demands.

Figure 30 depicts the 12 major water supply systems, while Table 35 contains data essential to them.

#### Major Water Supply Systems within Albany County.

City of Albany -- The City of Albany Water Department is the largest water system in operation within the UMA, providing more than 130,000 people with over 22 mgd. Its sources of water are the Alcove and Basic Reservoirs, which have a combined safe yield of 28.4 mgd. The water is treated in a 32-mgd capacity plant, and then distributed to the entire city except the undeveloped Pine Bush section.

Town of Colonie -- The Latham Water District is the major supplier of the Colonie area, and draws its water from the Stony Creek Reservoir, which has a safe yield of 4.8 mgd. Four wells, having a combined capacity of 5.0 mgd, are used continuously with the Reservoir to meet the normal demands of the Latham Water District. Seven other wells can provide an additional 4.1

TABLE 35

KNOWN WATER SUPPLIES

ALBANY-SCHENECTADY-TROY UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| City of Albany Dept. of Water | 130,000 | 22.0 | Surface | Alcove & Basic Reservoirs | 28.4 | 32.0 | 30.0 | 28.4 |
| Town of Colonie Latham Water District | 49,800 | 5.0 | Surface | Stony Creek Reservoir | 4.8 | 6.0 | 8.0 | 8.0 |
| | | | | Wells | 5.0 | | | |
| City of Cohoes Dept. of Water | 23,500 | 6.7 | Surface | Mohawk River | 100.0+ | 15.0 | 15.0 | 15.0 |
| Town of Bethlehem Dept. of Water | 19,050 | 1.1 | Surface | Vly Creek Reservoir | 3.1 | 4.0 | 4.0 | 3.1 |
| | | | | Wells | 2.0 | | | |
| City of Watervliet Dept. of Water | 18,000 | 3.9 | Surface | Watervliet Reservoir | 9.4 | 5.0 | 4.3 | 4.3 |
| City of Troy Dept. of Water | 87,500 | 21.0 | Surface | Tomhannock Reservoir | 47.0 | 30.0 | 47.0 | 30.0 |
| City of Rensselaer Dept. of Water | 13,700 | 2.2 | Surface | Hudson River | 100.0+ | 4.1 | 8.0 | 4.1 |
| City of Schenectady Dept. of Water | 103,300 | 17.5 | Ground Water | Wells | 27.0+ | -- | -- | 27.0 |
| Town of Rotterdam Dept. of Water | 23,000 | 1.7 | Ground Water | Wells | 10.0 | -- | 4.0 | 4.0 |
| City of Saratoga Springs Dept. of Water | 17,000 | 3.1 | Surface | Loughberry & Bog Meadow Brook | 3.0 | 5.0 | 3.0 | 3.0 |
| City of Mechanicville Dept. of Water | 7,600 | 1.0 | Surface | Mechanicville Reservoir | 1.5 | 2.0 | 2.0 | 1.5 |
| Village of Scotia Dept. of Water | 11,000 | 1.1 | Ground Water | Wells | 4.0 | -- | 2.6 | 2.6 |

mgd, but their use at present is restricted to periods of peak demand. In the mid 1960's, the total average water demand was 5.0 mgd.

Those areas of Colonie not within the Latham District obtain their supply either from private wells, or from neighboring municipal systems.

City of Cohoes -- The Cohoes Water Department serves about 23,500 residents of the city and of Green Island Village. Total demand in the mid 1960's was about 6.7 mgd.

The water supply of the Cohoes Water Department is diverted from the Mohawk River and treated in a 15 mgd treatment plant. Because the flow in the Mohawk River is closely regulated upstream for purposes of navigation, more than 100 mgd are available for water supply as the Mohawk joins the Hudson River at its confluence at Cohoes.

Town of Bethlehem -- Since 1956, Bethlehem Water District No. 1 has been supplied by the Vly Creek System, which serves about 81% of the town's population. The South Albany Water Corporation is the only other public water utility in the town.

In the mid 1960's, the Vly Creek System served a population of about 17,800 people with average water usage of about 1.0 mgd. The Vly Creek Reservoir has a safe yield of 3.1 mgd, while another 0.4 mgd are provided from two deep wells.

City of Watervliet -- The city of Watervliet is located south of Cohoes on the Hudson River, and has a population of 18,000 inhabitants. It obtains its water supply from the Watervliet Reservoir, which has a safe yield of approximately 9.4 mgd. The average demand on the system has been about 3.9 mgd.

Major Water Supply Systems within Rensselaer County.

City of Troy -- The city of Troy water supply system provides water to Troy, and to Brunswick, Village of Menands (Albany County), North Greenbush, and Schaghticoke. The system serves 87,500 inhabitants with approximately 22 mgd. Its primary source of supply is the Tomhannock Reservoir, which has a safe yield of 47 mgd. Other smaller sources include Dunham and the Martin-Brunswick-Vanderheyden Reservoirs and a few ponds.

City of Rensselaer -- The Rensselaer Public Water Supply serves the entire city of Rensselaer, and Water Districts Numbers 1, 2, and 3 of East Greenbush. Data for 1960 indicate that about 13,500 people were supplied with their demand of 2.2 mgd. The only source at the time was the Hudson River, from which two 4-mgd pumps drew the water through intakes into sedimentation tanks of 200,000 gallons combined capacity. The water then flows by gravity into a 4.12-mgd filtration plant.

Major Water Supply Systems within Schenectady County.

City of Schenectady -- The water supply system of the city of Schenectady served a population of about 103,300, whose total water demand was about 17.5 mgd, in the mid 1960's. The supply comes from twelve gravel-packed wells along the Mohawk River having a pumping draft capacity of between 27 and 35 mgd, depending on natural conditions. The water is supplied to the entire city, and to portions of the Town of Niskayuna, and Water District No. 1 in Rotterdam.

Town of Rotterdam -- Water District Numbers 4 and 5 of the Town of Rotterdam served a mid-1960's population of 23,000 with an average water supply of 1.7 mgd. The water was obtained from three gravel-packed wells, with drafts of from 4 to 6 mgd. The wells supply the water distribution system directly from transmission mains.

Village of Scotia -- The Village of Scotia System supplies water to all of Scotia, to the U.S. Naval Depot, and to Water District Numbers 2, 3, 8 and 12 in the Town of Glenville. The total population served in the mid 1960's was about 11,000, and used an amount of water averaging 1.1 mgd. Supply sources are three wells in a sand and gravel aquifer, from which the water was pumped to a reservoir of 530,000-gallon capacity, and thence to the distribution system. The aquifer is estimated to have a firm yield of 4 mgd.

Major Water Supply Systems within Saratoga County.

City of Saratoga Springs -- Approximately 17,000 people, whose average demand amounted to 3.1 mgd, were served in the mid 1960's by the Saratoga Springs Water Supply System. The major water sources of the city are Loughberry Lake and Bog Meadow Brook, which have a combined safe yield of about 3.0 mgd.

City of Mechanicville -- The public water supply facilities of the city of Mechanicville served all of the city, the Water District No. 1 in the town of Halfmoon, and Schaghticoke Water District No. 2. The total population of these areas numbered 7,600; the water demand was over 1 mgd. The sources of the city reservoir supply, the safe yield of which is about 1.5 mgd, are two impounding reservoirs, having a total capacity of 134 million gallons, on Plum Brook and Baker Brook.

Future Adequacy

The developed capability of surface water and ground water aquifers amounts to about 133 mgd. This amount is sufficient to meet the projected demands through the year 1980, but a deficit of over 50 mgd will occur by 2000, as shown on Table 36.

TABLE 36

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

ALBANY-SCHENECTADY-TROY UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 93.0 | 124.0 | 183.3 | 249.8 |
| Present Capability (mgd) | 132.8 | 132.8 | 132.8 | 132.8 |
| Deficit (mgd) | -- | -- | 50.5 | 117.0 |

## DESIRABILITY FOR REGIONALIZATION

Although only on a small scale, regionalization has been effected in several areas of the UMA for a number of years. The city of Troy, for example, provides water to a large section of Rensselaer County, and also to Menands Village in Albany County, across the Hudson River. The city of Mechanicville is in Saratoga County, and supplies two water districts outside of the city - one in the town of Halfmoon, and the other across the Hudson in the town of Schaghticoke.

As the UMA expands in population and in developed land area, the desirability for broader regionalization becomes more apparent. To combine the resources of the existing water utilities, especially the major ones, would be to insure an adequate and dependable water supply for the growing Albany-Schenectady-Troy UMA.

## DEVELOPMENT ALTERNATIVES

Because the UMA is quite large, and because water availability from surface and ground water sources is abundant, many alternatives exist for meeting the expected demand of nearly 250 mgd for the year 2020.

Water supply studies have been completed for the four counties of the UMA, Albany, Rensselaer, Saratoga and Schenectady, with numerous alternatives for meeting the expected urban area needs resulting. A brief summary of the consultants' recommended proposals for each of the counties follow.

### Albany County

The recommended proposal for Albany County provides for two water service areas, the Northeast Service Area and the Central Service Area. In the former, the three water systems of Cohoes, Watervliet, and Green Island would be interconnected, with the Watervliet Reservoir and the Mohawk River, through the Cohoes intake, as the sources of water supply. The intermunicipal area would be serviced in its entirety.

The Central Service Area is proposed to include all of Albany and parts of Bethlehem, Guilderland, and New Scotland. Surplus water from the Watervliet Reservoir would be treated and transmitted to Guilderland and to the water service area of the city of Albany. Water to Bethlehem and New Scotland would be provided by tapping Albany's existing transmission main from the Alcove and Basic Reservoirs system. Eventually, water would be diverted from the Mohawk River to supplement the available supply from the Watervliet Reservoir.

### Rensselaer County

For all practical purposes, the Troy system and Tomhannock Reservoir supply water to most of the urban areas within the County. Because the yield of the reservoir is 47 mgd, the source will be adequate to meet the growing demands throughout the service area for a number of years. At present, the excess capacity of the reservoir is about 27 mgd.

### Saratoga County

It has been recommended that Great Sacandaga Lake be utilized to supply almost all of Saratoga County, because the lake has an enormous yield. Flow records indicate that, on the average, more than 1,350 mgd flow out of the lake. The demand for the Saratoga County water district would be only 4 percent of the daily outflow. In fact, the total demand anticipated for the entire UMA would be less than 20 percent of the daily outflow.

### Schenectady County

The consultants for Schenectady County have recommended that the existing water supply systems be joined together with appropriate pumping and transmission facilities to form one county water supply utility. Because the ground water aquifers have a much larger potential yield than is at present being used, no additional wells need be drilled until after 2000.

### Capital District Region

The Capital District Regional Planning Commission, which serves all four counties, has concluded in its recent study that, as an additional opportunity for water supply development, it would be advantageous for consolidation and interconnection of the water supply facilities of these counties.

## CONCLUSIONS

Water availability throughout the four counties in the UMA is more than sufficient to meet the demands anticipated through the year 2020. At present, the supply capabilities of the existing systems will be able to meet the overall water requirements beyond the year 1980; however, water deficits may be experienced sooner in local areas within the UMA because of transmission, treatment, or distribution limitations.

Each of the four counties has completed comprehensive water supply studies in preparation for the future. The conclusions and recommendations reached in these plans are regional in nature, and certainly are adequate to prepare for the expected demands on an individual county basis.

Mass interconnections and mutual utilization of existing sources of water as proposed by the Capital Regional Planning Commission, would insure that the major water supply sources located within each county would be available to all counties, if the need should arise,

# CHAPTER 11. UTICA-ROME

The Utica-Rome Urban Metropolitan Area, shown on Figure 31, covers 370 square miles in the central portion of New York State. About two-thirds of the area lies in the upper Mohawk Valley, while the remaining third is in the Oswego River Basin, and includes Lake Oneida. The UMA comprises the densely populated centers in Oneida and Herkimer Counties, and a portion of Madison County including the city of Oneida and its environs. Those components expected to be a part of the UMA by the year 2020 follow:

<u>Herkimer County</u>

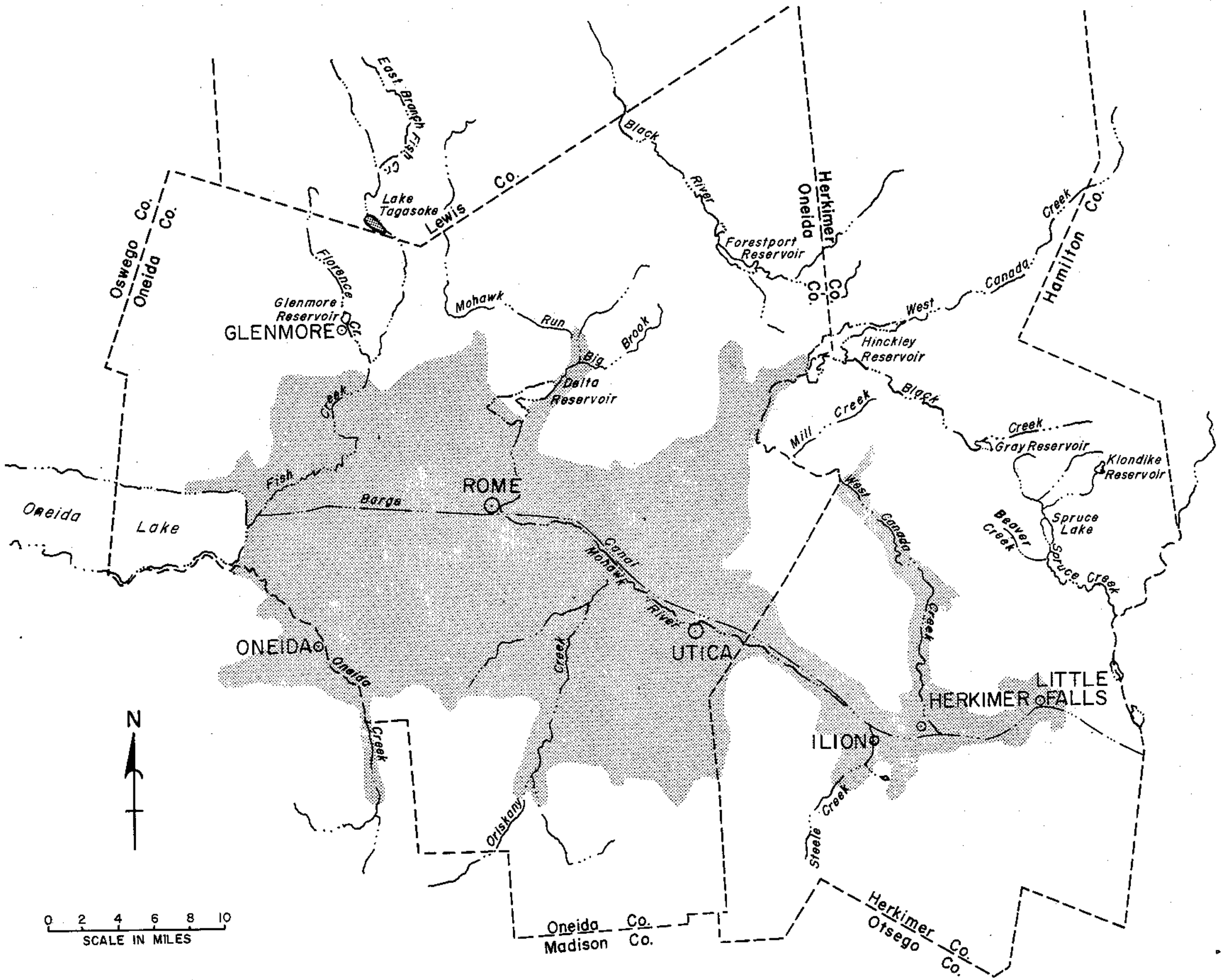
Danube town (part)
Fairfield town (part)
  Middleville village (part)
Frankfort town (part)
  Frankfort village
German Flatts town (part)
  Ilion village
  Mohawk village
Herkimer town (part)
  East Herkimer
  Herkimer village
Little Falls city
Little Falls town (part)
Manheim town (part)
  Dolgeville village
Newport town (part)
  Middleville village (part)
  Newport village
  Poland village (part)
Shuyler town (part)

<u>Madison County</u>

Lenox town (part)
  Canastota village
  Wampsville village
Oneida city
Stockbridge town (part)
  Munnsville village

<u>Oneida County</u>

Deerfield town (part)
Floyd town (part)
Kirkland town (part)
  Clark Mills
  Clinton village
Lee town (part)
Marcy town (part)
Marshall town (part)
New Hartford town (part)
  New Hartford village
  New York village (part)
Paris town (part)
  Clayville village
Remsen town (part)
  Remsen village (part)
Rome city
Rome town (part)
Sherill city
Trenton town (part)
  Holland Patent village
  Prospect village
  Remsen village (part)
  Trenton village
Utica city
Vernon town (part)
  Oneida Castle village
  Vernon village
Verona town (part)
Vienna town (part)




UTICA-ROME UMA

FIGURE 31

Oneida County (con't)

Westmoreland town (part)
Whitestown town (part)
  New York Mills village (part)
  Oriskany village
  Whitesboro village
  Yorkville village

Features of the topography include Oneida Lake; the easterly-flowing Mohawk River and its valley; the upland front of the Appalachian Plateau to the south of the Mohawk River; and the rolling upland plateau, which extends into the Adirondack Mountains, to the north.

Oneida Lake, the largest in the Oswego River Basin, has a surface area of 80 square miles, 21 miles long and from 4 to 5 miles wide. Its shores are low and flat, with large swampy areas on all sides. The level of the lake, normally about 370 feet above mean sea level, is regulated by a dam at Caughdenoy. The New York State Barge Canal traverses the lake.

As a result of glaciation and subsequent water erosion, land surface varies considerably in elevation and slope. Altitudes range from 420 feet above sea level in the Mohawk Corridor, to nearly 600 feet on valley terraces of the northern front of the Appalachian Plateau, south of the Mohawk River; summit heights are 1,000 to 2,000 feet above sea level. The land to the north of the river slopes gradually upward to 1,500 feet in northern Oneida County, and to 2,500 feet where portions of Herkimer County extend into the Adirondacks.

The climate of the area is generally classified as moist continental, with long cold winters and short mild summers. The mean temperature at Utica is about 46°F, with recorded temperature extremes of -28°F and 100°F. The average precipitation amounts to approximately 40 inches, with an annual runoff of about 22 inches recorded below Delta Dam on the Mohawk River, near Rome.

The economic and industrial development of the area is centered in the cities of Rome and Utica, within a natural transportation corridor extending from the Hudson Valley to the Great Lakes. Principal industries include apparel and related products; food and kindred products; textile mill products; printing and publishing; primary metal industries; and fabricated metal products. Passenger and freight conveyance are provided by Interstate Route 90, rail service, scheduled flights to the Utica Municipal Airport by Mohawk Airlines, and the New York State Barge Canal.

## POPULATION

The population centers currently include the cities of Little Falls, Oneida, Rome, and Utica, and the villages of Herkimer and Ilion. The four cities and two villages accommodate a population of more than 180,000, or over one-half of the entire UMA population, according to 1970 census data. All of these centers lost population during the past decade because of the trend toward suburbanization: significant numbers of people have moved from the cities to the "bedroom" communities surrounding the large industrialized areas. In the last decade, the towns and villages surrounding the city of Utica noted a collective 13 percent increase in population, while the city's population declined by 8 percent.

Between the years 1960 and 1970, the UMA components increased in total population by 2 percent. Population projections for the UMA indicate a 99 percent increase by the year 2020. Projected population and density figures are shown in Table 37.

TABLE 37

POPULATION DATA

UTICA-ROME UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| **Population (in thousands)** | 320.5 | 328.0 | 389.0 | 480.0 | 636.5 |
| **Population per square mile** | 865 | 885 | 1050 | 1295 | 1720 |

## WATER USAGE

Available data indicate that more than 95 percent of the UMA population was served by water systems throughout the UMA in the mid 1960's. Average publicly supplied municipal and industrial demand was about 46 mgd, obtained from developed sources having a collective capacity of approximately 66 mgd. It is estimated that by the year 2020, the UMA will require 124 mgd to satisfy M & I water requirements, or an increase of almost 200 percent over the mid-1960's demand.

Projections for water usage for the UMA are shown in Table 38, while Figure 32 depicts graphically the trends in population and M & I water use.

## KNOWN WATER SUPPLIES

### Summary

Herkimer and Oneida Counties are endowed with excellent surface water and adequate ground water resources. At present, over 95 percent of all of the UMA's water is obtained from surface sources.

Approximately 26 utilities provide water to the communities within the expected UMA. Most of the utilities are relatively small, serving one village or limited population centers from locally developed sources that have little or no potential for future development. Usually, the supply capabilities barely exceed the average daily demands made on these small utilities.

Six of the water supply systems may be considered major utilities, providing more than one mgd to at least one municipality or water district. In the mid 1960's, two of the utilities, owned and operated by the cities of Rome and Utica, supplied 35 mgd from two sources, the East Branch of Fish Creek, and Hinckley Reservoir. The aggregate safe yield of these two sources was 73.5 mgd (available for water supply), while their combined capability was 70 percent greater than the total amount provided by the 6 major utilities of the UMA at that time. The two systems owned by Rome and Utica are the only major utilities which are capable of increasing their supply of water from existing sources.

TABLE 38

WATER USAGE

UTICA-ROME UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 31.0 | 44.0 | 63.0 | 94.0 |
| Publicly-supplied industrial | 15.0 | 16.0 | 19.0 | 30.0 |
| TOTAL M & I | 46.0 | 60.0 | 82.0 | 124.0 |
| Publicly-supplied industrial | 15.0 | 16.0 | 19.0 | 30.0 |
| Self-supplied industrial | 29.0 | 29.0 | 29.0 | 29.0 |
| TOTAL INDUSTRIAL | 44.0 | 45.0 | 48.0 | 59.0 |
| Water Use (gcd) (Based on M &I) | 148.0 | 154.0 | 171.0 | 195.0 |

POPULATION AND M&I WATER USE
UTICA-ROME UMA

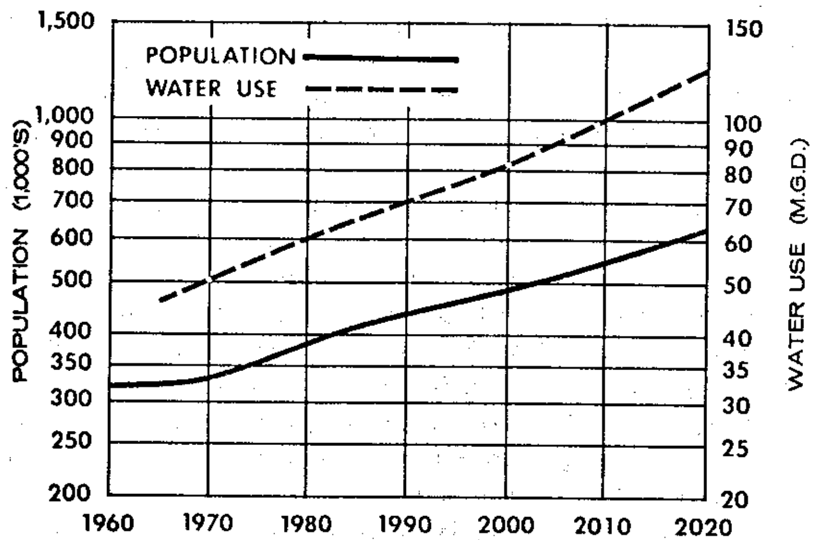



FIGURE 32

The city of Utica operates the largest water supply system, and provides about 22 mgd, from sources presently capable of 48.5 mgd, to service areas located within the towns or municipalities of Clark Mills, Deerfield, Frankfort, Kirkland, Marcy, New Hartford, New York Mills, Oriskany, Russia, Schulyer, Trenton, Utica, Washington Mills, Whitesville, and Yorkville. The population served by the Utica system is more than 142,000, nearly 45 percent of the population currently residing in the UMA.

The installation of additional transmission and treatment facilities would increase system capacity to its full capability, 48.5 mgd. However, the city of Utica is bound by an agreement with New York State to provide for an impoundment reservoir, capable of storing 6 billion gallons, above Hinckley Reservoir. At present, Utica has accounted for 1.2 billion gallons by the maintenance of Gray Reservoir on Black Creek; but until the remaining 4.8 billion gallons of storage is constructed, diversion rights from Hinckley Reservoir, that would increase the Utica system to 48.5 mgd, will not be granted.

The city of Rome water system serves the next largest population of over 50,000, throughout the inner incorporated city and portions of the towns of Lee and Western, from water diverted from the East Branch of Fish Creek. Under an agreement with the State, Rome can divert up to 25 mgd from this source; however, present demand on the system requires that only one-half of this amount be diverted.

The city of Oneida system serves more than 17,000 people, both within the city and in the surrounding communities of Durhamville, Wampsville, Oneida Castle, Sherrill, and Vernon. A small impoundment on Florence Creek having a safe yield of 3.5 mgd provides the bulk of Oneida's supply.

The city of Little Falls and the villages of Herkimer and Ilion provide water service to a combined population of about 33,000 within their respective service areas. The city-owned system of Little Falls serves the entire city and a small portion of the surrounding area. Herkimer supplies the village and the hamlet of East Herkimer, while Ilion provides water throughout the village and to small areas in East Frankfort and South Ilion.

Each of these systems, however, operates as a separate entity, with its own source of water supply and its own management systems. No interconnections between any of them are

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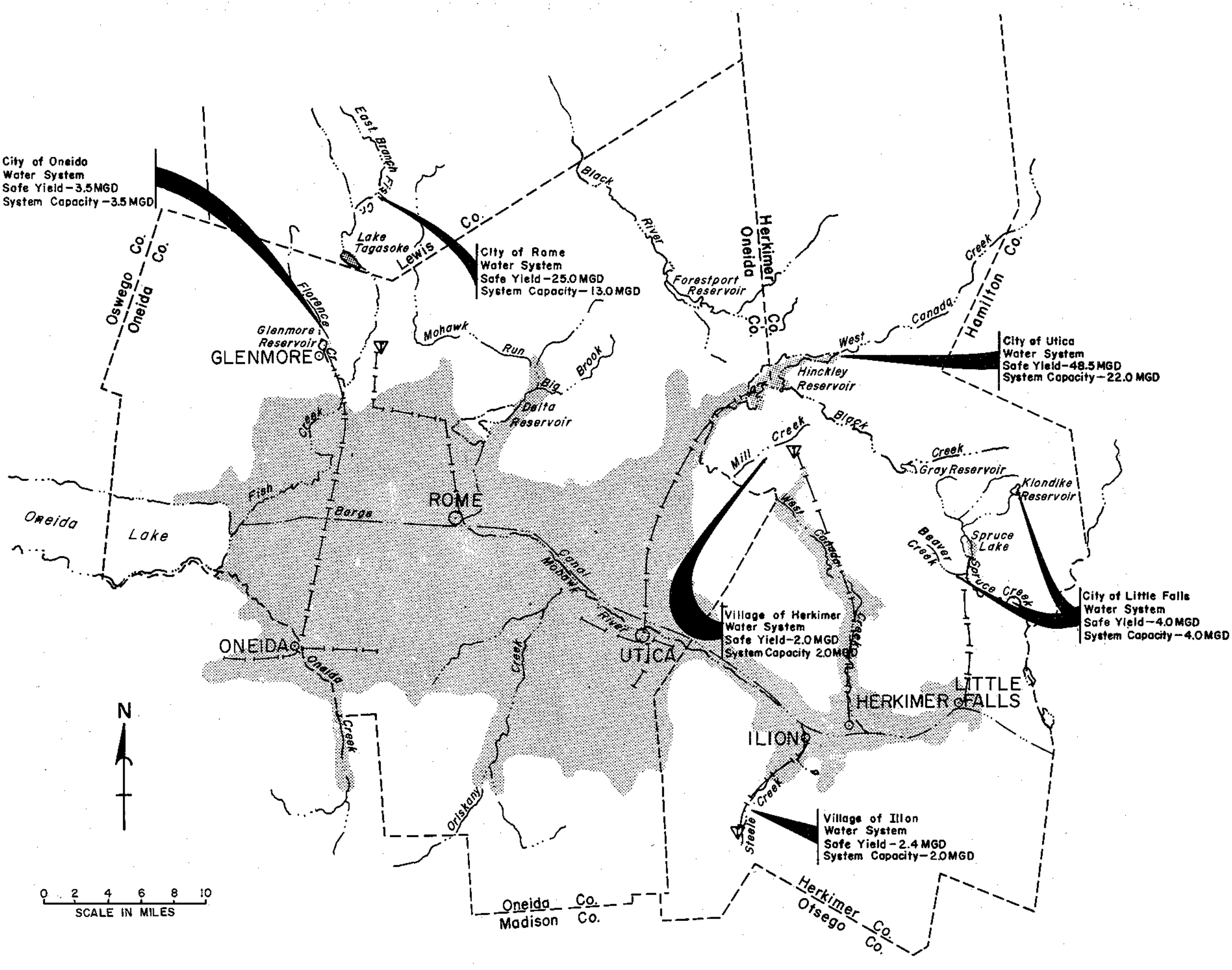



**KNOWN WATER SUPPLIES**
**UTICA-ROME UMA**
**FIGURE 33**

known to exist.

Figure 33 shows the six major water utilities of the cities of Little Falls, Oneida, Rome, and Utica, and the villages of Herkimer and Ilion; Table 39 contains essential data for each.

TABLE 39

KNOWN WATER SUPPLIES

UTICA-ROME UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Village of Herkimer Water System | 12,000 | 1.8 | Surface Reservoir | Mill Creek | 2.0 | N/A | 2.85 | 2.0 |
| Village of Ilion Water System | 12,000 | 1.3 | Surface Reservoirs | Steele Creek Watershed Clappsaddle Creek Hawkes Creek Litchfield Creek | 2.4 | 2.0 | 2.0 | 2.0 |
| City of Little Falls Water System 1/ | 9,000 | 2.0 | Surface Reservoirs | Beaver Creek King Springs Klondike Reservoir (Spruce Creek) | 4.0 | N/A | 4.0 | 4.0 |
| City of Oneida Water System | 17,000 | 3.0 | Surface Reservoirs | Glenmore Reservoir (Florence Creek) | 3.5 | 3.5 | 3.5 | 3.5 |
| City of Rome Water System | 50,000 | 13.0 | Surface Reservoir | East Branch of Fish Creek 2/ | 25.0 | -- | 30.0 | 13.0 |
| City of Utica Water System | 142,000 | 22.0 | Surface Reservoirs | Hinkley Graffenburg 3/ | 48.5 | -- | 30.5 | 22.0 |

1/ The city of Little Falls is required by the state of New York to release 6.0 mgd down Spruce Creek; safe yield of its reservoirs excludes this requirement.

2/ Boyd Dam, located in Lewis county, impounds more than 1.4 bg in Lake Tagasoke which is used to regulate the downstream flow in the East Branch of Fish Creek. Thus the city of Rome can divert up to 25 mgd from the East Branch of Fish Creek which has a dry weather yield of 41 mgd.

3/ Under an agreement with New York State, the city of Utica can divert up to 48.5 mgd from Hinckley Reservoir if it provides 6 bg of storage upstream. Presently, the city maintains Gray Reservoir on Black Creek, a tributary to Hinckley Reservoir, with a storage capacity of 1.2 bg.

## Future Adequacy

At present, the total capacity of the six major systems can be determined as 67 mgd, by combining their respective capacities, as shown in the preceding table. However, a reduced combined capacity of 46.5 mgd is shown in Table 40, for two reasons, based on information received from the state of New York. First, it is apparent that Utica and Rome are continuing to supply water from surface sources to their present service area, without providing treatment required by the state. Second, the mandated storage reservoir of 4.8 bg above Hinckley Reservoir has not as yet been constructed. The 46.5 mgd figure, therefore, was obtained by an arbitrary reduction of the Utica and Rome systems capacities to their average supply in the mid 1960's, 22 and 13 mgd, respectively.

Construction of treatment plants, transmission facilities, and the impoundment above Hinckley Reservoir, would increase the total capacity to 85 mgd, thereby precluding the 2000 deficit.

TABLE 40

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

UTICA-ROME UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 46.0 | 60.0 | 82.0 | 124.0 |
| Present Capability (mgd) | 46.5 | 46.5 | 46.5 | 46.5 |
| Deficit (mgd) | -- | 13.5 | 35.5 | 77.5 |

## DESIRABILITY FOR REGIONALIZATION

Each of the six major systems qualifies as a regional supply, because all provide water to more than one municipality. However, four of the six operated by the cities of Little Falls and Oneida and the villages of Herkimer and Ilion, are utilizing their existing surface water supplies at capacity, though without exceeding safe yield. Engineering evaluation by consultants discloses that very little opportunity exists to increase to an appreciable amount, the capacity of any of the four systems' sources.

A greater degree of regionalization could be effected if each of the six major systems investigated interconnection, with the necessary pumping, transmission, and treatment facilities, to utilize the full potential of existing water-supply resources for the entire UMA. The establishment of a water supply authority, responsible for the overall administration and utilization of existing and potential water resources appears to be the best way to accomplish a totally regional approach to water supply.

## DEVELOPMENT ALTERNATIVES

A number of opportunities for improving the water supply situation throughout the Utica-Rome UMA have been proposed by various consultants and governmental agencies. A summary follows.

### Proposed Plans

In 1968, "Herkimer and Oneida Counties Comprehensive Public Water Supply Study," was prepared for the two counties. Various alternatives were proposed to meet the projected water supply demand through the year 2020.

#### Oneida County.

The plan for the western part of Oneida County includes joint use of the surface water sources now being used by the cities of Oneida and Rome, respectively. Water from Glenmore Reservoir, belonging to the city of Oneida, and from the East Branch of Fish Creek, used as a source of water by the city of Rome, would be gravity fed to a new 26-mgd common treatment plant. After treatment, the water would be supplied separately to the Oneida and Rome systems through existing and newly installed transmission mains. Phase Two of the project would include expansion of the Glenmore Reservoir watershed to 21.3 square miles and increase of the storage capacity by about two billion gallons. Treatment facilities would be expanded to 37 mgd after 1990.

The project for the eastern part of Oneida County includes adding about 11.3 billion gallons of storage on branches of West Canada Creek, to allow increased withdrawals from Hinckley Reservoir. Water would be treated at a 34-mgd treatment plant, which would be expanded to 62 mgd after 1990. New transmission mains would be installed to convey the water to the expanded urban area.

Herkimer County.

The proposed project for the western part of Herkimer County entails expanding the existing Herkimer system by providing about 20 million gallons of storage on Jarvis Brook, a branch of West Canada Creek. Villages would be connected along the existing transmission main following West Canada Creek above Herkimer, and a 30-mg storage tank would be constructed. After 1990, an 8.7-mgd treatment plant would treat water from West Canada Creek to supply Herkimer, Mohawk, Ilion, and Frankfort, on the south side of the Mohawk River. The possibility of purchasing water wholesale from the Utica system, for storage in the proposed 30-mg reservoir in Herkimer, also presents a favorable solution for supplying the expanding urban area, and would further enhance a regional water-supply concept throughout the UMA.

Phase One of the project for the eastern part of Herkimer County includes the construction of a 2.7 mgd treatment plant as an addition to the existing Little Falls system, and construction of transmission mains to include Dolgeville and Salisbury. Phase Two entails expanding the treatment plant to about 4.0 mgd, after 1990.

Thus, the proposals for meeting the water demands throughout the UMA would be met in two phases, one after 1970 and the other after 1990. Treatment plant capacities for the Oneida and Herkimer projects would provide 65 mgd and 113 mgd for the respective phases. The plan report shows that estimated costs for the project are $35,990,000 for Phase One, and $93,640,000 for Phase Two. Annual costs have not been included in these estimates.

During the time period between 1990 and 2020, an additional 11 mgd will have to be provided to meet the projected 2020 requirement of 124 mgd. This could be accomplished by increasing total capacity of the proposed treatment plants throughout the system.

## Development of Potential Reservoir Sites

Herkimer and Oneida Counties have an abundance of surface water and, to a lesser extent, ground water resources. Twelve reservoir sites have been marked as projects, for initial development or for expansion; they are listed in Table 41, and shown graphically on Figure 34. If all of these are implemented, then about 840 mgd for water supply would be provided. Thus, there is more than enough water potentially available, either within or near the two counties, to satisfy the water supply requirements of the UMA far beyond the year 2020.

## Diversion of Water From Lake Ontario

Various studies, including the NEWS Study for the Northern New Jersey - New York City - Western Connecticut Area, have proposed the diversion of water from Lake Ontario as a possible method of water supply.

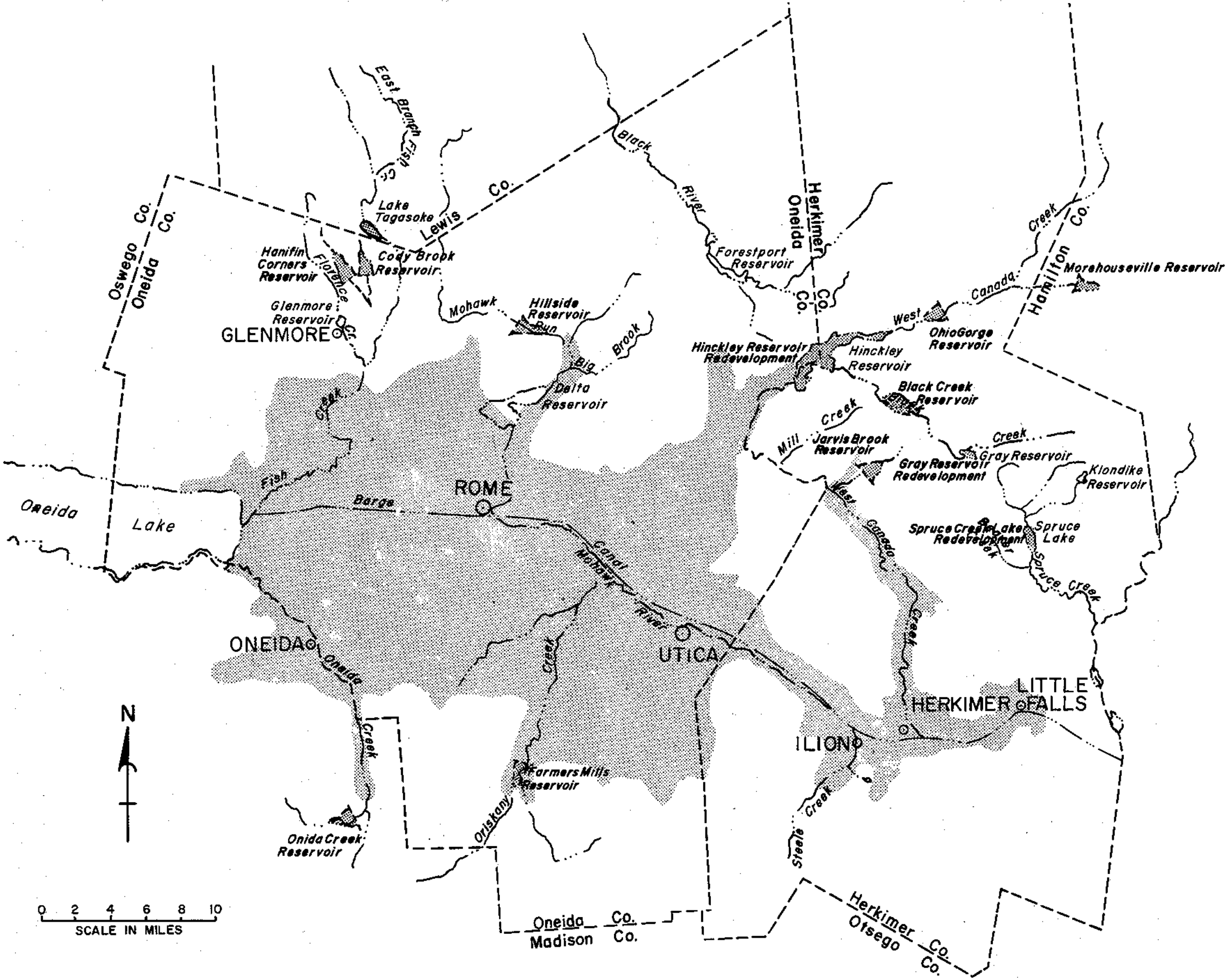
In such a scheme, pumping stations and transmission mains could be constructed to supply water to Oneida Lake, and then transfer this water, via a tunnel, into the Mohawk River. Water could then be taken from the Mohawk River, treated, and used for water supply throughout the UMA.

## Ground Water Development

Ground water in the Utica-Rome vicinity occurs in two distinct types of aquifers, both amenable to development. First, the glacial deposits of sand and gravel which generally form the river valleys can be developed to yield moderate to large quantities of water. Second, overburden or underlying bedrock, outside the river valley areas, can supply smaller amounts of water.

Yields from the glacial deposits range from 200 to 500 gallons per minute; some existing wells produce as much as 1 mgd. Yields from existing wells, drilled into bedrock consisting of shale, sandstone, limestone, or granite crystalline rocks, average about 8 gallons per minute. These wells are used primarily for individual domestic supplies.

Ground water development within the Oneida River Basin, encompassing the western portion of Oneida County and the eastern portion of Madison County has been in general unsuccessful, because of salt contamination.

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POTENTIAL RESERVOIR SITES
UTICA-ROME UMA

FIGURE 34

## TABLE 41

## POTENTIAL RESERVOIR SITES

| Name | Stream | Drainage Area (sq. mi.) | Total Storage mg | Safe Yield mgd |
|---|---|---|---|---|
| Hanifin Corners | Florence Creek | 12 | 1,400 | 8.0 |
| Cody Brook | Cody Brook | 3.9 | 350 | 2.2 |
| Hillside | Mohawk River | 75 | 28,000 | 94 |
| Morehouseville | West Canada Creek | 41 | 6,500 | 61.5 1/ |
| Ohio Gorge | West Canada Creek | 225 | 6,500 | 61.5 1/ |
| Hinckley | West Canada Creek | 373 | 145,000 | 480 |
| Jarvis Brook | Jarvis Brook | 0.2 | 20 | 1.1 |
| Black Creek | Black Creek | 103 | 5,000 | 48.5 1/ |
| Gray | Black Creek | 25.3 | 6,000 | 48.5 1/ |
| Spruce Lake | Spruce Creek | 36 | 1,900 | 19 2/ |
| Farmers Hill | Oriskany Creek | 75 | 1,600 | 21 3/ |
| Oneida Creek | Oneida Creek | 18.5 | 1,400 | 9 |
| Total | | | | 854.3 |

1/ Yield based on providing 800-mg storage for each additional 6.5-mgd diversion from Hinckley Reservoir.

2/ Includes 6-mgd allowance for downstream riparian users.

3/ Includes 8-mgd Barge Canal diversions and allowance for downstream use.

With the exception of the needs of individuals and, perhaps, a few industrial users, extensive ground water development does not appear necessary, because such an abundance of surface water sources and developments exists.

## CONCLUSIONS

A deficit of nearly 78 mgd is projected for the Utica-Rome UMA for the year 2020. Large deficits within the UMA may well be experienced sooner, unless adequate plans and facilities are implemented in the near future. The yields of sources of water available for development are far in excess of anticipated deficits, but storage, treatment, and transmission capacity must be increased.

It is evident that the concept of regionalization was of foremost concern in the planning efforts by Oneida and Herkimer Counties and their consultants. Each of the recommended proposals for the several areas is regional in its attempt to preclude the water deficits expected to occur during the next fifty years. However, an overall water supply management for the entire UMA, should be established, to administer an integrated program whose goal is the realization of maximum potential resource development.

# CHAPTER 12. SYRACUSE

The Syracuse Urban Metropolitan Area is located in the north central portion of New York State. The area encompasses most of Onondaga County, (part of Oswego County), and the urbanized corridor extending from Onondaga County along the Oswego River to Lake Ontario.

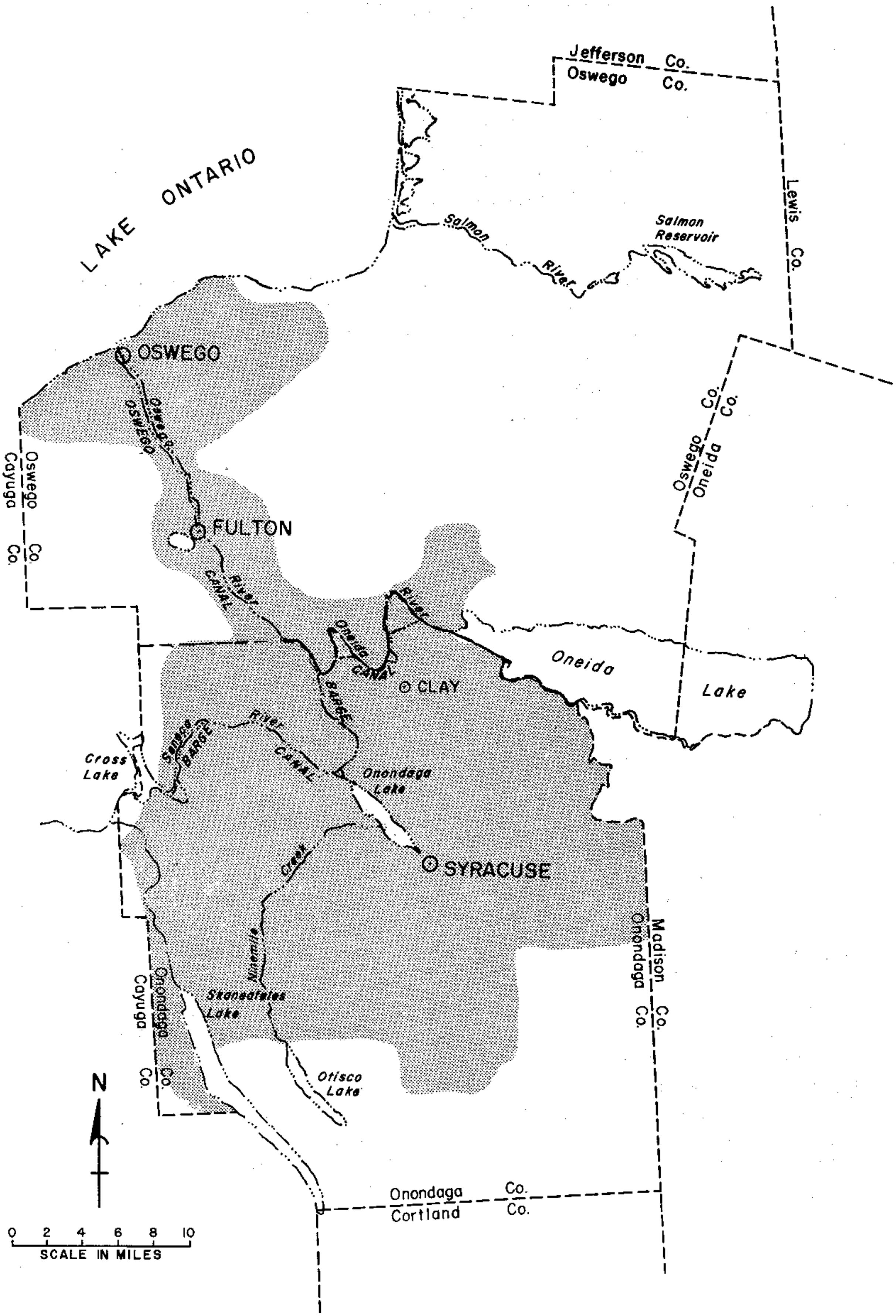
The principal centers of population within the UMA are the city of Syracuse and its environs in Onondaga County, and the cities of Oswego and Fulton in Oswego County. The UMA that is expected to evolve by the year 2020 will cover an area of approximately 800 square miles; it is delineated on Figure 35. The components of the UMA, in whole or in part within its boundaries, include:

Onondaga County

- Camillus town
  - Camillus village
  - Fairmount (u) (part)
- Cicero town (part)
  - Boysen Bay (u)
  - Brewerton (u)
  - North Syracuse village (part)
- Clay town
  - North Syracuse village (part)
- DeWitt town
  - Dewitt (u)
  - East Syracuse village
- Elbridge town
  - Elbridge village
  - Jordan village
- Geddes town
  - Fairmount (u) (part)
  - Solvay village
  - Westvale (u)
- Lafayette town (part)
- Lysander town (part)
  - Baldwinsville village (part)
- Manlius town
  - Fayetteville village
  - Manlius village
  - Minoa village
- Marcellus town
  - Marcellus village
- Onondaga town
- Salina town
  - Liverpool village
  - Mattydale (u)
- Skaneateles town
  - Skaneateles village
- Syracuse city
- Van Buren town
  - Baldwinsville village (part)

Oswego County

- Fulton city
- Granby town (part)
- Hannibal town (part)
  - Hannibal village
- Hastings town (part)
  - Brewerton (u) (part)
  - Central Square village
- Minetto town
- New Haven town (part)
- Oswego city
- Oswego town
- Schroeppel town
  - Phoenix village
  - Sand Ridge (u)

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**SYRACUSE UMA**
**FIGURE 35**

Oswego County (con't)

Scriba town
Volney town
West Monroe town (part)
  Brewerton (u) (part)

The climate of the area is generally classified as continental. The mean temperature is about 48°F, with extremes ranging from -26°F to 102°F. Average precipitation amounts to approximately 37 inches, with an average runoff of 19 inches.

The topography of the UMA differs throughout: the southern portion is extremely hilly country, while the central portion is characterized by rolling hills. Along the shores of Lake Ontario, the land is relatively flat. Elevations range from 250 feet above sea level in and around the city of Oswego, to 1,700 feet in the southern region. There are four major lakes in the area, the Skaneateles, Otisco, Onondaga, and Oneida Lakes. The New York State Barge Canal traverses Oneida Lake, Oneida River, and Seneca River in an east-west direction. The Oswego River and Oswego Canal connect the Barge Canal with Lake Ontario at the city of Oswego.

Economic and industrial development is centered primarily in the city of Syracuse. Important industries include food, apparel and textiles, printing and publishing, chemicals, fabricated metals, and paper and allied products. An excellent transportation network consists of several interstate highways, the New York State Barge Canal and rail and air service. Good transportation has been a significant factor in the continuing economic and industrial growth throughout the area.

## POPULATION

The cities of Syracuse, Fulton, and Oswego had a combined population of more than 235,000, according to the 1970 census, or more than 40 percent of the population of the entire UMA. Between 1960 and 1970, the UMA components showed an overall increase in population of more than 12 percent.

Projections indicate that the UMA will almost double its present population during the fifty-year study period. Population and density figures are shown in Table 42.

TABLE 42

POPULATION DATA

SYRACUSE UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 480.3 | 539.2 | 600.9 | 760.9 | 940.3 |
| Population per square mile | 600 | 675 | 750 | 950 | 1,175 |

## WATER USAGE

Available data indicate that in the mid 1960's, approximately 403,000 people were served by water supply systems throughout the UMA. The average publicly supplied municipal and industrial demand at that time was about 84 mgd. It is expected that by the year 2020, the UMA will require 239 mgd to satisfy municipal and industrial water requirements, an increase of more than 180 percent over the present demand.

The projections for water demand are shown on Table 43, while Figure 36 illustrates the trends of population and M & I water demands for the UMA during the study period.

## KNOWN WATER SUPPLIES

### Summary

Most of the nineteen water supply systems within the UMA are publicly owned, and have a combined capacity of about 126 mgd. Five systems are major suppliers, owned and operated respectively by the Onondaga County Water Authority (OCWA), the Onondaga County Water District (OCWD) (administered by the Metropolitan Water Board), and the cities of Oswego, Fulton, and Syracuse. In the mid 1960's, they provided an average daily demand of about 82 mgd to a population in excess of 400,000. Sixty-six percent of the 82 mgd was utilized for municipal purposes, while the remaining 34 percent was supplied to industry. Industries obtained an additional 34 mgd from private sources.

TABLE 43

WATER USAGE

SYRACUSE UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 56.0 | 91.7 | 132.4 | 187.6 |
| Publicly-supplied industrial | 28.0 | 28.0 | 33.0 | 51.0 |
| TOTAL M & I | 84.0 | 119.7 | 165.4 | 238.6 |
| Publicly-supplied industrial | 28.0 | 28.0 | 33.0 | 51.0 |
| Self-supplied industrial | 34.0 | 34.0 | 34.0 | 34.0 |
| TOTAL INDUSTRIAL | 62.0 | 62.0 | 67.0 | 85.0 |
| Water Use (gcd) (Based on M & I) | 208.0 | 200.0 | 217.0 | 254.0 |

**POPULATION AND M&I WATER USE**
**SYRACUSE UMA**

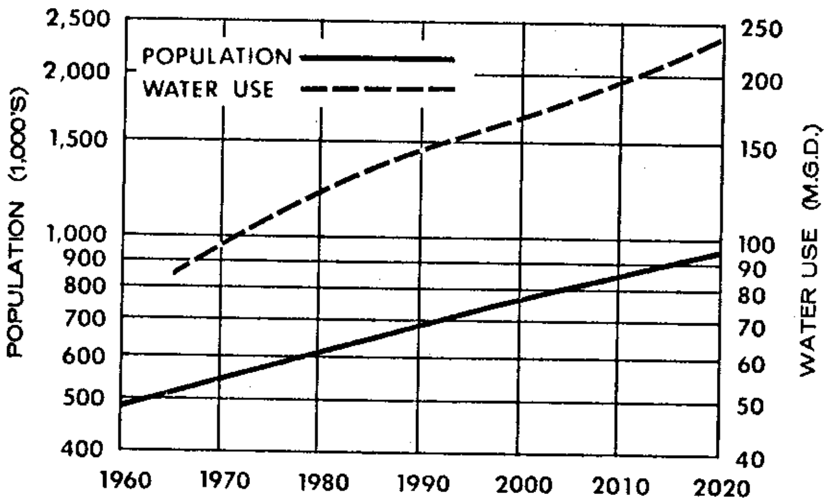



FIGURE 36

Syracuse maintains the largest supply system, which utilizes Skaneateles Lake as its main source of water. The New York State Water Resources Commission, however, has limited the City to a total withdrawal rate of 68 mgd, because the towns of Skaneateles and Elbridge have prior rights to the water for supply. Furthermore, withdrawal rates above the set limit would be detrimental to the numerous residences and camps at the lake. For operational reasons, the City has chosen to limit its rate to 43.5 mgd. The City purchases water for its low service area from the OCWD, whose source is Lake Ontario.

The Syracuse system served about 245,000 people in the mid 1960's, both throughout the city and in portions of the towns of Camillus, Dewitt, Elbridge, Geddes, Manlius, Onondaga, Salina and Skaneateles.

The OCWA obtains its supply of water from Otisco Lake, but is limited by the Water Resources Commission to a total withdrawal rate of 20 mgd, because the lake is used as part of the water supply system for the Barge Canal. The OCWA utility serves more than 120,000 people throughout portions of the towns of Camillus, Cicero, Clay, Dewitt, Geddes, Lysander, Manlius, Marcellus, Onondaga, Salina and Van Buren. The OCWA is at present drawing its full allocation of water from Otisco Lake, and in addition is buying water on a wholesale basis from the OCWD.

The city of Fulton supplies water to a population of about 14,600 throughout the city, and to areas within the towns of Granby and Volney. Ground water from nine wells, with a reported yield of 3.75 mgd, is the main source of supply used to meet the 2.0 mgd demand. In emergencies such as drought or fire, the City is able to draw water from Lake Neatahwanta.

Lake Ontario is the source of water for the city of Oswego. The system provides about 11 mgd to more than 22,000 people, both throughout the city and to parts of the towns of Minetto and Oswego. The City may draw unlimited amounts from Lake Ontario; but it has yet to comply with a directive from the Water Resources Commission requiring filtration, in addition to chlorination, of all water from this source.

The OCWD has the capacity to treat and transmit 36 mgd from its facilities on the shores of Lake Ontario. At present, it has two main customers, the city of Syracuse and the OCWA.

Figure 37 shows the five major water supply systems of the UMA, and Table 44 contains essential data concerning each of them.

TABLE 44

KNOWN WATER SUPPLIES

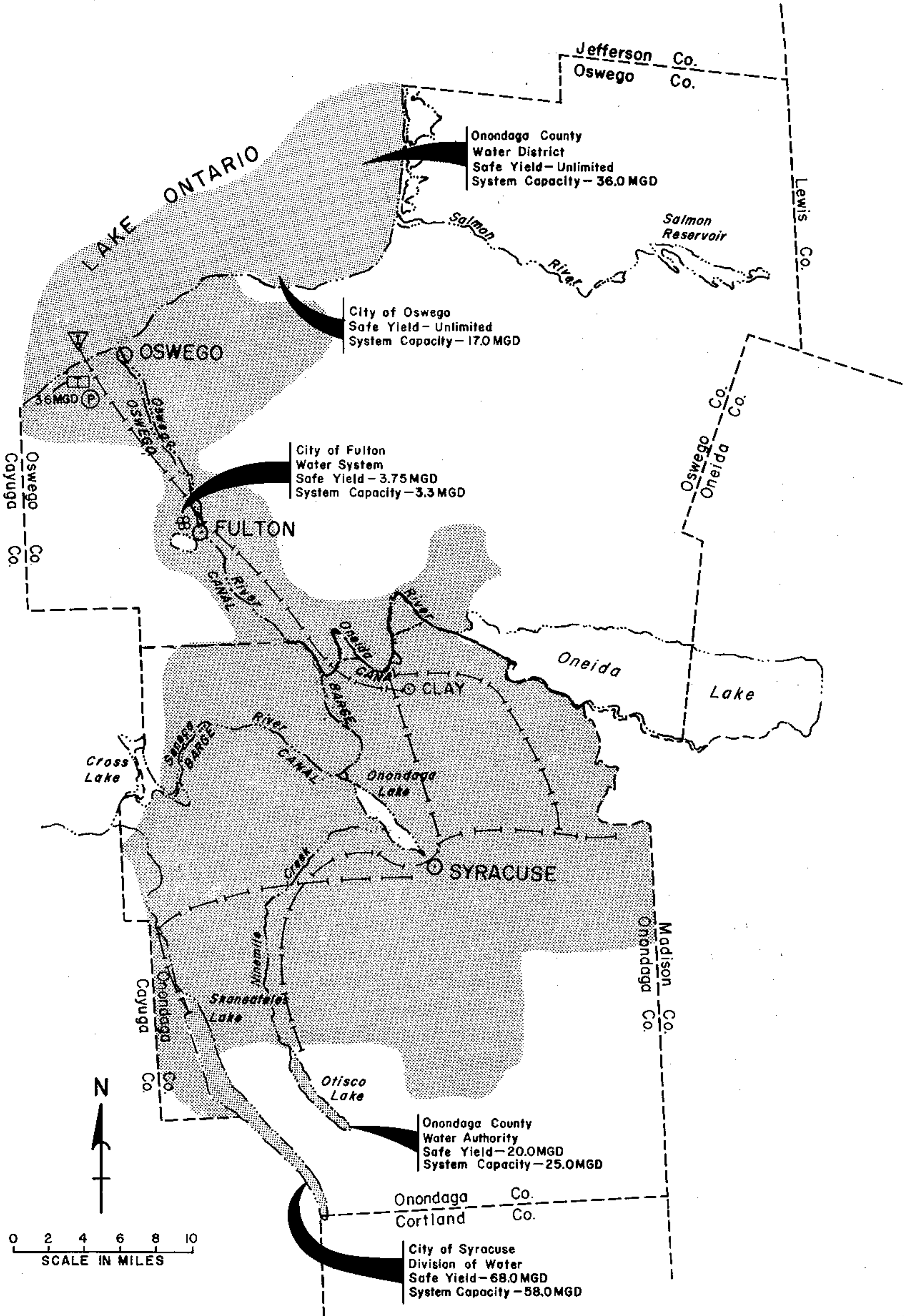
SYRACUSE UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| City of Fulton Water System | 14,600 | 2.0 | Ground Water Wells - 9 | | 3.75 | -- | N/A | 3.3 |
| Onondaga County Water Authority | 120,000 | 20.0 | Surface Reservoir | Otisco Lake | 20.0 | -- | 25.0 | 25.0 1/ |
| Onondaga County Water District | N/A | N/A | Surface Reservoir | Lake Ontario | Unlimited | 36.0 | 36.0 | 36.0 |
| City of Oswego | 22,000 | 11.0 | Surface Reservoir | Lake Ontario | Unlimited | -- | N/A | 17.0 |
| City of Syracuse Division of Water | 245,000 | 43.5 | Surface Reservoir | Skaneateles Lake | 68.0 | -- | 58.0 | 58.0 1/ |

1/ Purchases some water from OCWD

## Future Adequacy

As shown in Table 44, the combined capacity of the five known water supply facilities amounts to about 139 mgd. As shown in Table 45, this amount of water will not be sufficient by 2000 to meet the projected requirement of some 164 mgd. The OCWD was placed in operation in 1967, with a peak day capacity of 36 mgd from Lake Ontario. However, the OCWD can readily double its present capacity of 36 mgd by increasing the size of its filter plant and increasing its pumping capacity; therefore, in all probability the 2000 deficit shown will not materialize. The city of Fulton has decided to expand its well field to meet the added water demand expected for the next several years.

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**KNOWN WATER SUPPLIES**
**SYRACUSE UMA**
**FIGURE 37**

TABLE 45

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

SYRACUSE UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 84.0 | 119.7 | 165.4 | 238.6 |
| Present Capability (mgd) | 139.3 | 139.3 | 139.3 | 139.3 |
| Deficit (mgd) | -- | -- | 26.1 | 99.3 |

## DESIRABILITY FOR REGIONALIZATION

The desirability for regionalization within the Syracuse UMA has been fully recognized, and has already been implemented to a large degree. The combined service areas of the Syracuse Water System, the OCWA, and the OCWD include practically all of Onondaga County. The OCWD sells water on a wholesale basis to Syracuse and to the OCWA. It also has the responsibility of supplying water to the remaining communities in the county, except for Skaneateles and Spafford, but they are expected to join the District in the near future. Furthermore, the OCWD has an agreement with the city of Oswego to draw 62.5 mgd through the City's intake structure on Lake Ontario. Several taps exist along the transmission main from Oswego to the terminal reservoir in the town of Clay; most of the taps are in the vicinity of the city of Fulton.

## DEVELOPMENT ALTERNATIVES

The Onondaga County Comprehensive Public Water Supply Study (CPWS-21), lists 13 potential water supply sources, not including Lake Ontario. However, these bodies of water were not considered as alternative sources, either because they have already been developed to their full potential for water supply, or navigation requirements for the Barge Canal; or because the construction costs associated with their development makes them economically unfeasible. Existing ground water potential is suitable only for small-scale development; therefore, Lake Ontario is considered to be the only practical source of water for large-scale development to benefit the Syracuse UMA.

Two alternatives have been considered in this study. The first is to expand further the existing facilities on Lake Ontario of the OCWD, after it doubles its capacity to meet the 2000 demand; or to construct a second large treatment,pumping and transmission facility to meet the 2020 deficit.

The second alternative is to modify the proposed plan of supplying water from Lake Ontario to the New York City Area, via Oneida Lake and the Mohawk River Valley, to include the city of Syracuse. A combined pumping effort by New York and Syracuse would probably benefit both cities. The acceptance of this alternative, however, should mean consideration of a new treatment plant for Syracuse near Oneida Lake.

## CONCLUSIONS

The present study indicates that deficits of about 26 mgd in 2000 and 100 mgd in 2020 can be expected in the Syracuse UMA. The output of the OCWD can easily be raised to 72 mgd by augmenting the filter plant and pumping facilities, and this would meet the 2000 deficit. Further expansion or construction of an additional 73 mgd treatment, pumping and transmission facilities, however, are required to meet the 2020 deficit. Lake Ontario is the only reasonable source opportunity for the Syracuse UMA.

Under its present organization, the OCWD covers the entire county, except for the towns of Skaneateles and Spafford. It is authorized to sell water on a wholesale basis to the city of Syracuse, to the OCWA, and to areas within Oswego County. Thus, for all intents and purposes, a regionalized system does exist throughout Onondaga County. Furthermore, the OCWD shares the city of Oswego's intake structure, and by an agreement with Oswego, it can draw 62.5 mgd.

Because the city of Oswego must filter its water supply from Lake Ontario, it may be advantageous for the city and for the OCWD to arrange for the existing OCWD filtration plant to be expanded, to supply filtered water to the city of Oswego.

Taps have been added to the OCWD transmission main for the purpose of supplying specific areas within Oswego County, particularly in and around the city of Fulton.

To achieve the most effective regionalized system, all communities concerned should unite to establish an overall administrative body, which would be responsible for efficient utilization of existing resources, and for development of additional water capability to meet the future demands of the Syracuse UMA.

# CHAPTER 13. ROCHESTER

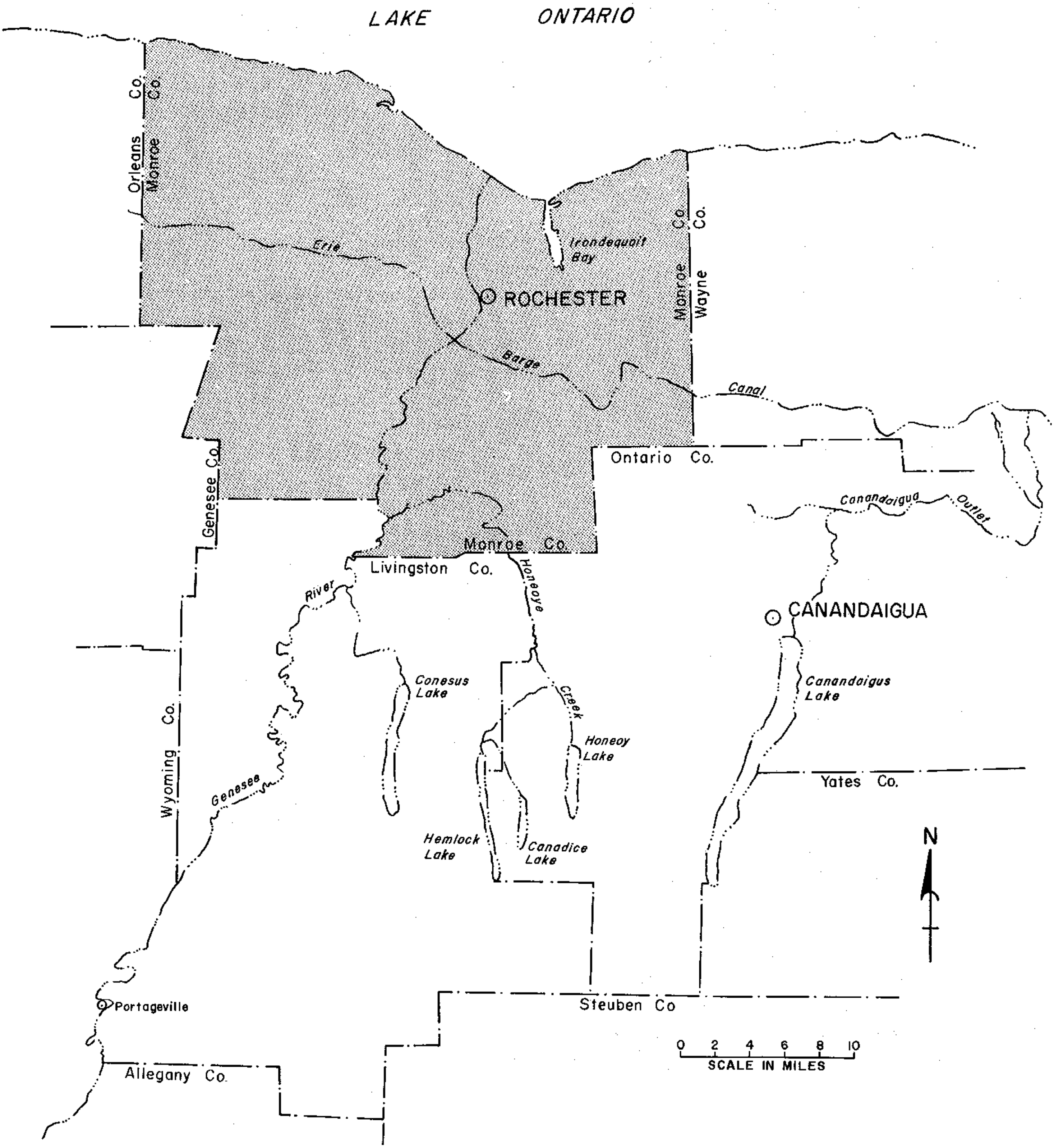
The Rochester Urban Metropolitan Area is in the northwestern portion of New York State, boardering on Lake Ontario. Because of the extensive economic and industrial growth now centered in and around the city of Rochester, the UMA expected to evolve by the year 2020 will encompass the entire 675 square miles of Monroe County, as shown on Figure 38. Its components are:

Monroe County

Brighton town
Chili town
  North Chili (u)
Clarkson town
  Brockport village (part)
Gates town
Greece town
Hamlin town
Henrietta town
Irondequoit town
Mendon town
  Honeoye Falls village
Ogden town
  Rolling Acres (u)
  Spencerport village
Parma town
  Hilton village
Penfield town
Perinton town
  East Rochester village (part)
  Fairport village
Pittsford town
  East Rochester village (part)
  Pittsford village
Riga town
  Churchville village
Rochester city
Rush town
Sweden town
  Brockport village (part)
Webster town
  Webster village
Wheatland town
  Scottsville village

The climate of the area is generally classified as humid continental, with cold winters and mild summers. The average temperature, influenced by Lake Ontario, is about 50°F, with mean temperatures during the winter months varying between 20°F and 30°F, and during the summer months, between 66°F and 70°F. Average precipitation is 30 inches, with an runoff of approximately 16 inches.

The topography of the area consists of gradually sloping terraces and undulating terrain. Altitudes vary throughout the region: they are about 250 feet above sea level on the shores of Lake Ontario; 640 feet in the Rochester vicinity; and 790 feet in the southern section. Topographic features include the Genesee River, flowing into Lake Ontario at Rochester, and the New York

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ROCHESTER UMA

FIGURE 38

State Barge Canal, which traverses the UMA in an east-west direction.

Rochester and its environs are the primary centers of economic and industrial development, at present. Principal industries include food, printing and publishing, chemicals, stone, clay, and glass, primary metals, fabricated metals, machinery, and instruments and related products. The excellent transportation system, including interstate highways, rail, air, and shipping services, has been a significant and continuing factor in the economic growth of the area.

## POPULATION

The foremost center of population includes the city of Rochester, and all contiguous towns and villages. Rochester's population, according to the 1970 census, was about 296,000; the figure represents a decline of 22,000 people between 1960 and 1970. However, the surrounding towns of Greece, Gates, Brighton, Penfield, and Irondequoit increased substantially in population - some by as much as 50 percent - during the same decade. These towns and Rochester accomodated a population in excess of 520,000, or approximately three-fourths of the population of the entire county for the year 1970.

Between 1960 and 1970, the components of the UMA showed an overall increase in population by more than 21 percent. Projections indicate that the area will continue its steady growth pattern, attaining an increase of 85 percent over the 1970 population by the year 2020. Population and density figures for the UMA are shown in Table 46.

TABLE 46

POPULATION DATA

ROCHESTER UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 586.4 | 711.9 | 897.0 | 1,052.0 | 1,318.0 |
| Population per square mile | 870 | 1055 | 1330 | 1560 | 1955 |

TABLE 47

WATER USAGE

ROCHESTER UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 77.0 | 101.2 | 148.1 | 212.2 |
| Publicly-supplied industrial | 20.0 | 30.0 | 59.0 | 98.0 |
| TOTAL M & I | 97.0 | 131.2 | 207.1 | 310.2 |
| Publicly-supplied industrial | 20.0 | 30.0 | 59.0 | 98.0 |
| Self-supplied industrial | 82.0 | 82.0 | 82.0 | 82.0 |
| TOTAL INDUSTRIAL | 102.0 | 112.0 | 141.0 | 180.0 |
| Water Use (gcd) (Based on M & I) | 146.0 | 146.0 | 197.0 | 235.0 |

POPULATION AND M&I WATER USE

ROCHESTER UMA

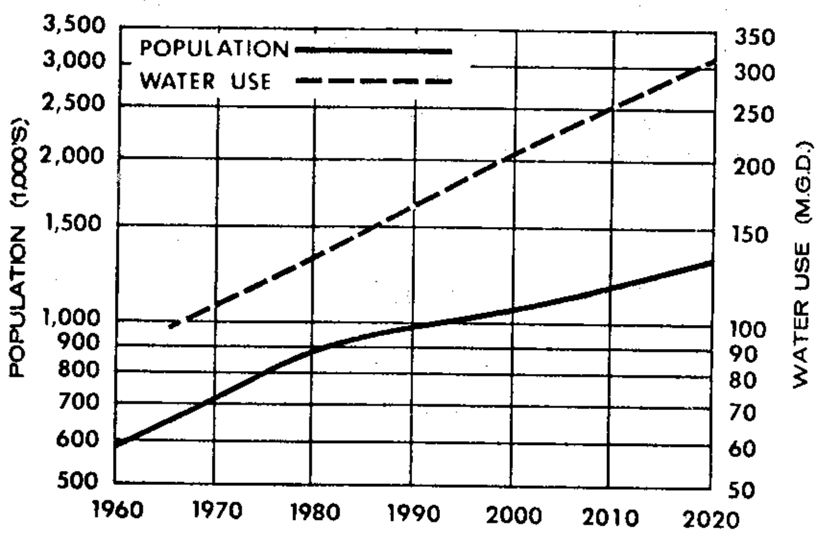



FIGURE 39

## WATER USAGE

Available data indicate that during the mid 1960's, about 663,000 people were served by large and small water supply systems throughout the UMA. The average publicly supplied M & I demand was at that time about 97 mgd. It is expected that by the year 2020, the UMA will require 310 mgd to satisfy M & I water requirements, or 320 percent of the current demand. The projections for water usage are shown on Table 47, and Figure 39 illustrates the population and M & I water demands projected for the UMA.

## KNOWN WATER SUPPLIES

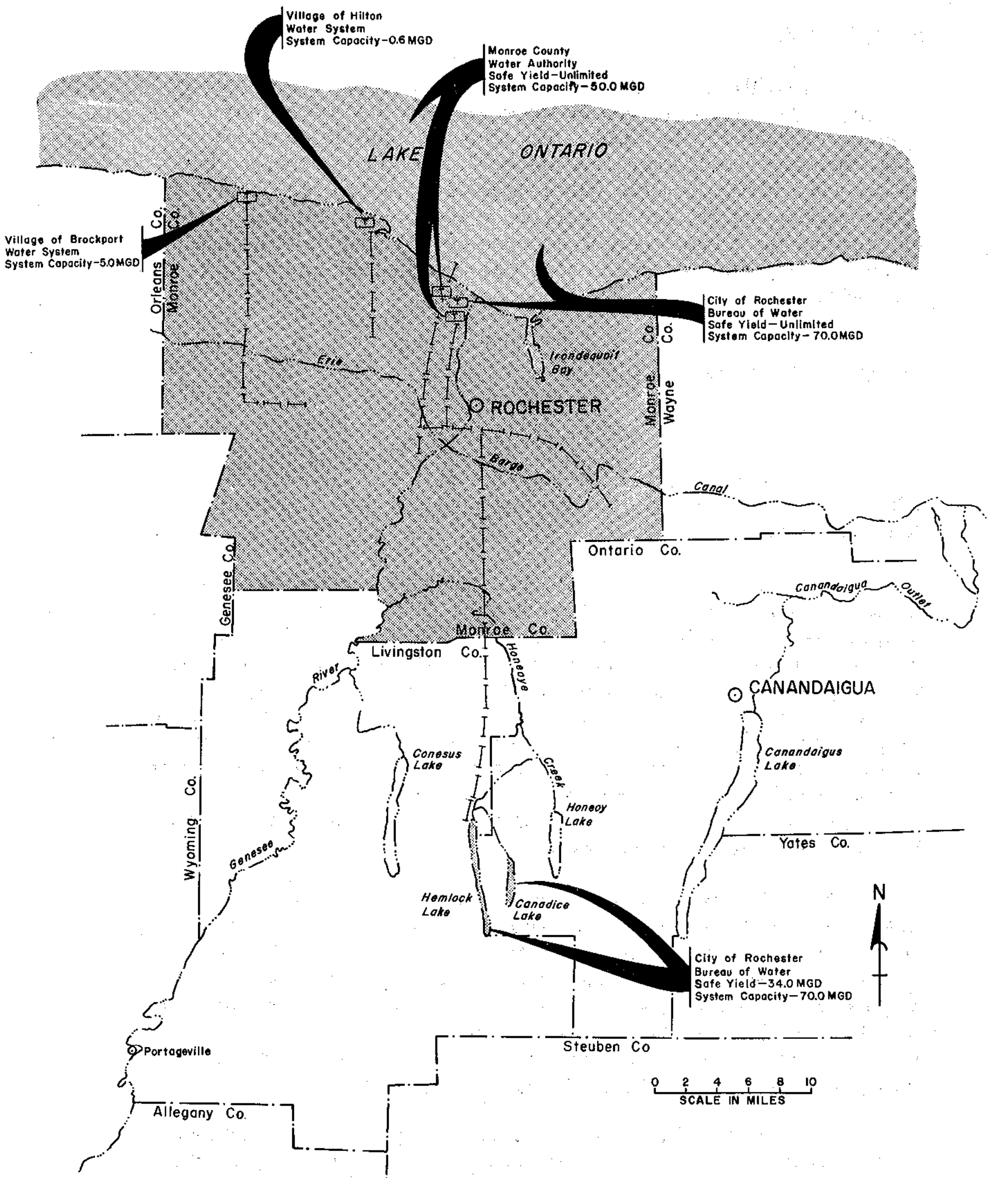
### Summary

Monroe County has two major suppliers of water: the City of Rochester Bureau of Water, and the Monroe County Water Authority (MCWA).

The City of Rochester Bureau of Water obtains its supply from Canadice and Hemlock Lakes in the Genesee Drainage Basin, approximately 30 miles south of the city. The combined safe yield of these two lakes amounts to about 34 mgd. Water is conveyed via three pipelines, having a total capacity of 48 mgd, to the city. The Bureau of Water serves more than 90 percent of the inhabitants within Rochester on a retail basis, and provides water to the hamlet of Hemlock and to the Monroe County Water Authority on a wholesale basis. The City also maintains a 36-mgd treatment plant on the shores of Lake Ontario, to supplement the Hemlock system, whenever necessary.

The Monroe County Water Authority at present supplies water on a wholesale or retail basis to 15 of the 19 towns in the county, and to that part of Rochester not served by the Bureau of Water. The MCWA supplies water to some of the small communities just outside the UMA boundaries: Macedon Water District No. 4, West Ontario Water District and Town of Walworth in Wayne County; and the High Street, North Farmington, North Bloomfield and Victor Water Districts in Ontario County.

The MCWA has two water treatment plants on the shores of Lake Ontario. The Shoremont Water Treatment Plant, larger of the two, has a capacity of 50 mgd, though expansion to 75 mgd




KNOWN WATER SUPPLIES
ROCHESTER UMA

FIGURE 40

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would be readily accomplished by installing more clarifiers, filter beds, and pumping facilities. An additional 25-mgd capacity gain could be realized by changing the filter media to allow faster filtration, and thus increase the total capacity to 100 mgd.

The Charlotte Water Treatment Plant, used on a part-time basis during summer periods of maximum consumption, is limited by the New York State Water Resources Commission to a rate of 12 mgd, because of its age.

Two small water treatment plants are located on the shores of Lake Ontario. The village of Brockport in the town of Sweden maintains a 5-mgd treatment plant in the town of Hamlin. Water from the treatment plant is supplied to areas along the transmission main, which runs southerly through the towns of Hamlin, Clarkson, and Sweden. The village of Hilton, in the town of Parma, maintains a 0.6-mgd treatment plant, which serves four water districts along the transmission main, within Parma.

Figure 40 shows the existing water supply systems, and Table 48 contains essential data concerning each of the major systems within the Rochester UMA.

### Future Adequacy

The combined capacity of the two major existing systems amounts to 120 mgd. This amount of water will not be sufficient by 1980, as can be seen in Table 49. However, the Monroe County Water Authority has anticipated the increased demands, and has formulated plans to expand substantially its treatment plant and transmission facilities during the 1970's. Therefore, a capacity of 190 mgd is shown for the benchmark year of 1980.

TABLE 48

KNOWN WATER SUPPLIES

MONROE COUNTY

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| City of Rochester Bureau of Water | 275,000 | 52.0 | Surface Reservoirs | Canadice Lake | 34.0 | 34.0 | 48.0 | |
| | | | | Hemlock Lake | | | | 70.0 |
| | | | | Lake Ontario | Unlimited | 36.0 | 36.0 | |
| Monroe County Water Authority | 245,000 | 32.0 | Surface Reservoirs | Lake Ontario | Unlimited | 50.0 | 50.0 | 50.0 |

TABLE 49

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

ROCHESTER UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 97.0 | 131.2 | 207.1 | 310.2 |
| Present Capability (mgd) | 120.0 | 190.0 | 190.0 | 190.0 |
| Deficit (mgd) | -- | -- | 17.1 | 120.2 |

## DESIRABILITY FOR REGIONALIZATION

For the most part, regionalization already exists throughout the Rochester UMA: the Monroe County Water Authority serves 15 of the 19 towns within the county, and has a close working relationship with the City of Rochester Bureau of Water. These two agencies have interconnections between their existing systems, and cooperate by exchanging water to serve customers within each other's water service areas. It has been suggested that the two systems effect further agreements to satisfy the water requirements throughout Monroe County, and eventually merge under one administration.

## DEVELOPMENT ALTERNATIVES

Several alternative courses of action have been proposed and investigated during the past several decades, to increase the water supply availability for Monroe County.

In 1927, the city of Rochester considered raising the level of Honeoye Lake by 30 feet for additional water supply which, in combination with Canadice and Hemlock Lakes, would provide a safe yield of 100 mgd. The proposal, however, was never implemented. In the 1950's, the City decided that Lake Ontario was the best source for future water supply development. Accordingly, Rochester constructed a 36-mgd treatment plant on the shores of

Lake Ontario to augment its upland reservoirs.

After investigating several alternative upland sites for water supply development, the Monroe County Water Authority decided that Lake Ontario, with its unlimited supply, was the best principal source of water. During the past decade, the MCWA has embarked on a series of construction programs which have resulted in one of the most modern and efficient water supply systems in the country.

The Genesee River Basin Coordinating Committee (GRBCC) and others have recommended the possibility of developing a reservoir at the Portage Demonstration Project site, using the storage capacity of the reservoir to insure an adequate supply of water. Several different schemes for conveying this water to the MCWA distribution mains have been proposed; one such is the utilization of the Genesee River in conjunction with an intake structure located closer to the UMA, thus saving the expense of building large transmission mains.

In the comparative cost analysis presented by the GRBCC concerning the Portage site as compared to Lake Ontario as sources of water, the committee estimated that average annual costs for the Genesee River source would be about one million dollars less than for Lake Ontario, primarily because of reduced power requirements. The Committee stated, however, that this annual cost does not reflect development costs for land acquisition or building the reservoir. Therefore, the GRBCC concluded that Lake Ontario is the most logical source of water to supply the water demand of the Greater Rochester Area. The city of Rochester and the Monroe County Water Authority, had previously arrived at the same conclusion.

## CONCLUSIONS

The present study shows that the Rochester UMA appears to have deficits over present capacity of 17 mgd in 2000 and 120 mgd in 2020. Local deficits could appear sooner; however, implementation of firm plans to construct additional treatment, pumping, and transmission facilities by the two major regional suppliers should prevent a potential water shortage from occuring. Thus, there is no actual source deficit.

Regionalization is being practised in the UMA. Although it is perhaps not as desirable as a single management, regionalization has been effective in supplying water to the UMA.

Major suppliers should implement their development plans during the fifty-year study period, to provide the additional water required for the Rochester UMA from Lake Ontario. The lake presents the most realistic alternative available. Eventually it may be advantageous for the city of Rochester to obtain its own water supply from Lake Ontario, either independently or in cooperation with the Monroe County Water Authority, and supply communities within the central plains area from its upland reservoirs.

# CHAPTER 14. BINGHAMTON

The Binghamton Urban Metropolitan Area is located within the limits of Broome County, which borders the Commonwealth of Pennsylvania, in the south-central portion of New York State. Urban centers are located along the Susquehanna River in the Triple Cities area - Binghamton, Endicott, and Johnson City.

The UMA that is expected to evolve by the year 2020 is shown on Figure 41. The area will encompass approximately 140 square miles, as suburbanization continues to spread from the Triple Cities area. The components that are totally or partially included within the UMA follow.

Broome County

Binghamton city
Binghamton town (part)
Chenango town (part)
  Nimmonsburg - Chenango Bridge (u)
Conklin town (part)
Dickinson town
  Port Dickinson village
Fenton town (part)
Kirkwood town (part)
Maine town
Union town
  Endicott village
  Endwell (u)
  Johnson City village
Vestal town
  East Vestal (u)
  Vestal - Twin Orchards
Windsor town (part)

The climate of the area is generally classified as moist continental, with long cold winters and short mild summers. The mean temperature is about 49°F, with extremes ranging from -28°F to 103°F. Average precipitation amounts to approximately 35 inches with an annual runoff of 21 inches, recorded at the USGS gage on the Susquehanna River in the town of Vestal.

The topography of the area is characterized by smooth, rolling hills in the northwest, and more rugged hills in the southwest; elevations vary from a low of 800 feet above sea level to over 2000 feet. The Susquehanna River and its primary tributaries, the Chenango River and Nanticoke Creek drain the area.

The present economic and industrial development is centered in the Triple Cities area. Primary industries include shoes and related products, machinery, electrical machinery, photographic equipment and supplies, ordnance, aircraft equipment, printing and publishing, and furniture.

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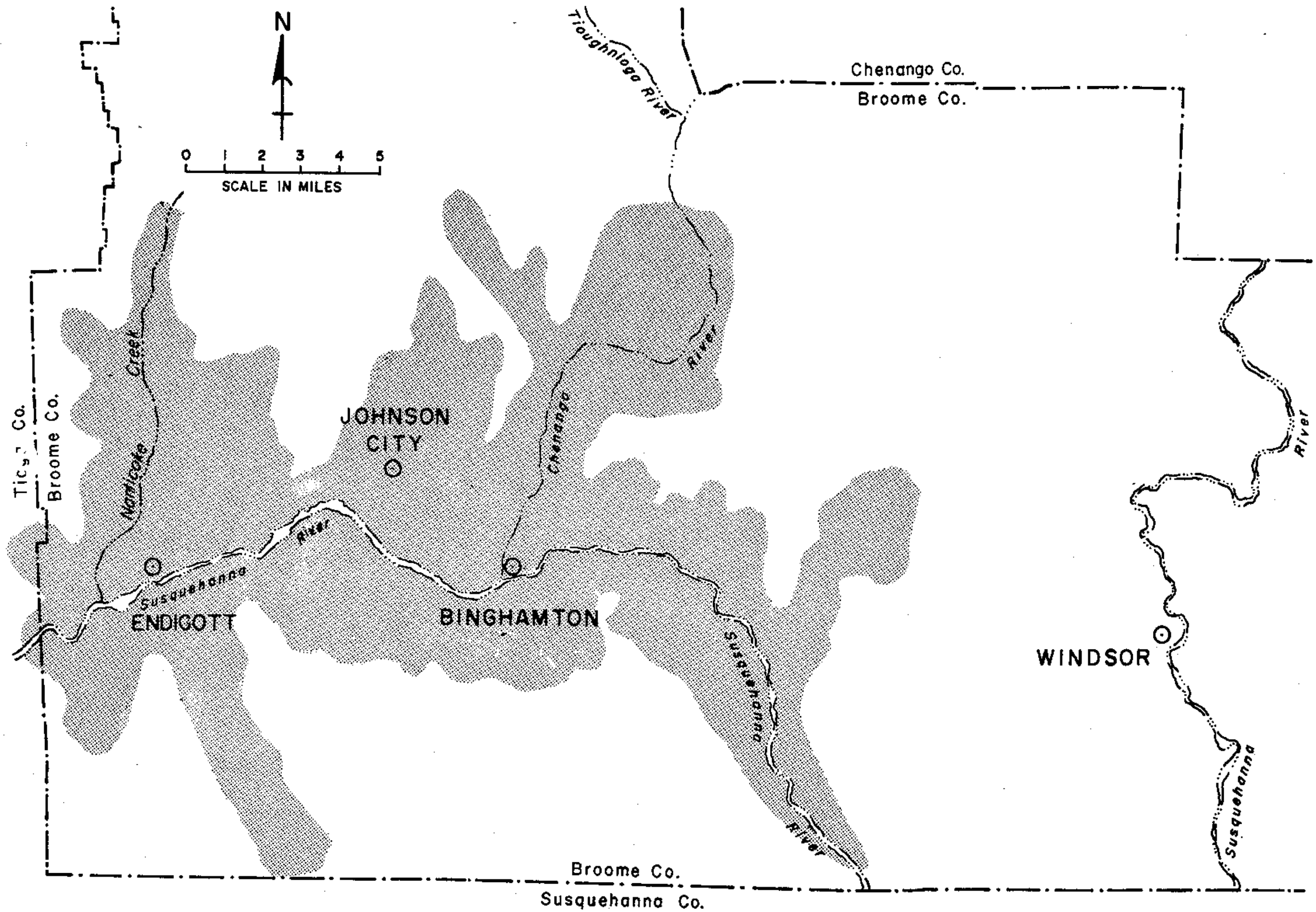



BINGHAMTON UMA

FIGURE 41

The Binghamton UMA is serviced by an excellent transportation network, which includes interstate highways, rail and air service.

## POPULATION

The major centers of population are the city of Binghamton and the villages of Endicott and Johnson City. Their combined population, according to 1970 census data, was about 98,700, or almost one-half of the population of the entire UMA for that year. During the ten year period between 1960 and 1970, the population of each of the above decreased, while the population of all of the other components of the UMA, except for Dickinson town and Port Dickinson village, increased. Projections indicate that the UMA will increase by more than 90 percent by the year 2020.

Population projections and density for the UMA are shown in Table 50.

TABLE 50

POPULATION DATA

BINGHAMTON UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 200.3 | 207.6 | 246.0 | 314.5 | 398.0 |
| Population per square mile | 1,430 | 1,480 | 1,755 | 2,245 | 2,845 |

## WATER USAGE

Published information discloses that both large and small water systems in the UMA served about 175,000 people in the mid 1960's. The average publicly supplied municipal and industrial demand then was about 30 mgd.

Projections for water usage are shown on Table 51. The table indicates that there is no expected proportional increase of

TABLE 51

WATER USAGE

BINGHAMTON UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 17.0 | 25.7 | 37.7 | 54.6 |
| Publicly-supplied industrial | 13.0 | 13.1 | 14.6 | 18.5 |
| TOTAL M & I | 30.0 | 38.8 | 52.3 | 73.1 |
| Publicly-supplied industrial | 13.0 | 13.1 | 14.6 | 18.5 |
| Self-supplied industrial | 7.0 | 7.0 | 7.0 | 7.0 |
| TOTAL INDUSTRIAL | 20.0 | 20.1 | 21.6 | 25.5 |
| Water Use (gcd) (Based on M & I) | 172.0 | 158.0 | 167.0 | 184.0 |

POPULATION AND M&I WATER USE

BINGHAMTON UMA

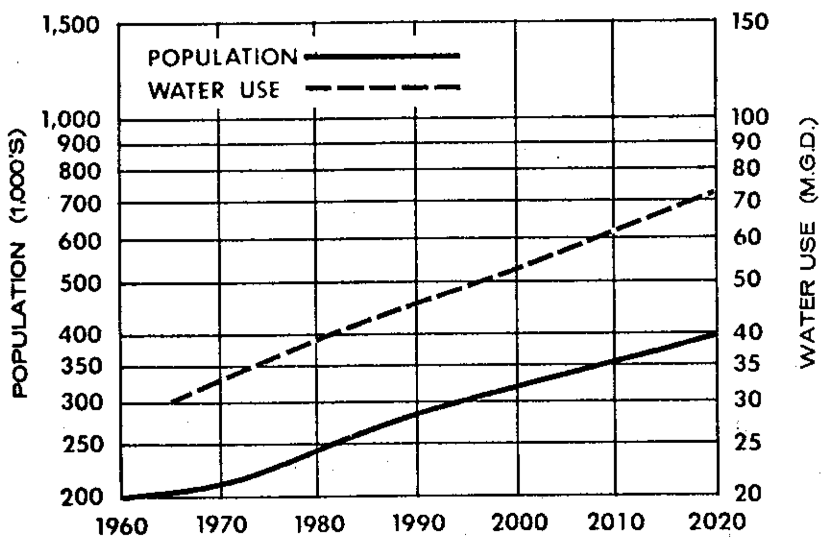



FIGURE 42

self-supplied industrial water to the increase in population. Future industrial water demand is difficult to predict, because the type of industry that might be drawn to an area varies. High water demand industries, such as steel or petroleum refining, are not likely to be attracted to south-central New York; future industrial growth of the Binghamton UMA is expected to be in the lighter industries which are not large water users, such as electronics and office machine manufacturing.

Figure 42 shows graphically the trends of population and water use for the period of study.

## KNOWN WATER SUPPLIES

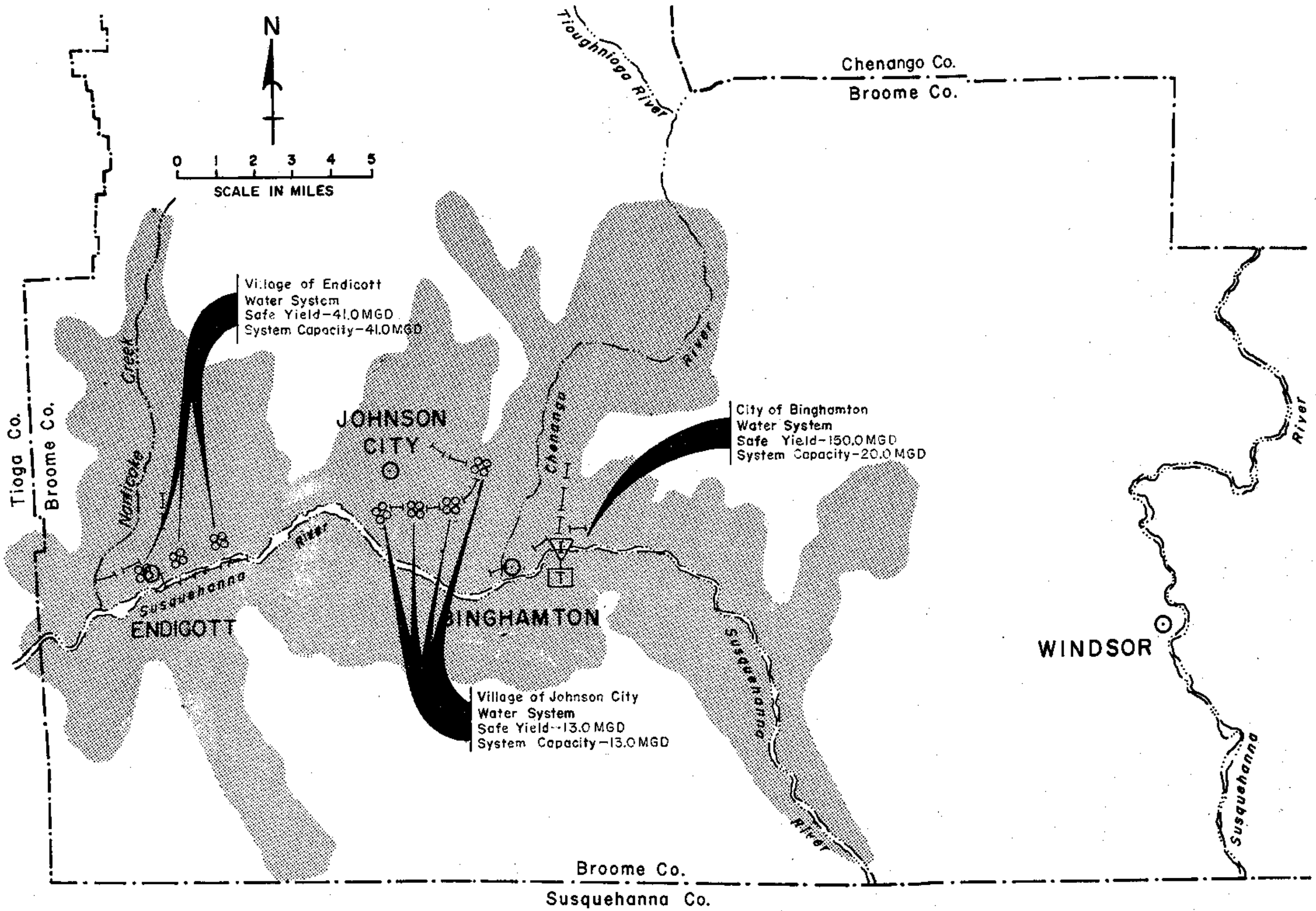
### Summary

Forty-three water systems, including 32 water districts, 4 municipal water agencies, and 7 private utilities, serve urbanized areas that will be an integral part of the UMA in 2020.

Of the 43, only 3 are major water suppliers, and they are owned and operated by the city of Binghamton and the villages of Endicott and Johnson City. Binghamton supplied an average demand of about 11 mgd, obtained from the Susquehanna River and treated in its 20-mgd treatment plant. The village of Endicott has 31 wells, the maximum draft of which is about 41 mgd, located on the north bank of the Susquehanna River. Approximately 9 mgd were supplied to the villages of Endicott and Endwell, and to portions of West Corners, Union and Vestal.

The village of Johnson City has seven wells located on a line through the center of the village. For short periods, these wells can yield up to 18 mgd, but the safe yield is 13 mgd. Approximately 7 mgd were supplied to the village of Johnson City and to portions of the towns of Dickinson and Union in the mid 1960's.

The three major systems, as can be seen in Table 52 and Figure 43, supplied approximately 27 mgd of water which included 13 mgd for industrial purposes in the mid 1960's, from sources with a combined capacity of 74 mgd.




KNOWN WATER SUPPLIES
BINGHAMTON UMA

FIGURE 43

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TABLE 52

KNOWN WATER SUPPLIES

BINGHAMTON UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| City of Binghamton | 75,000 | 11.0 | Surface | Susquehanna River | 150.0 | 20.0 | N/A | 20.0 |
| Village of Endicott Water System | 40,000 | 9.0 | Ground Water Wells - 31 | | 41.0 | -- | N/A | 41.0 |
| Village of Johnson City Water System | 25,000 | 7.0 | Ground Water Wells - 7 | | 13.0 | -- | N/A | 13.0 |

Future Adequacy

The resources of the Binghamton, Endicott and Johnson City systems available at present are sufficient to meet the projected water requirements through the year 2020. As shown on Table 53, the total developed water resources for all systems amount to 93 mgd, which is considerably greater than the demand of the entire UMA.

However, the water distribution systems are old, and in need of improvement. To meet the future requirements, the existing systems must be expanded, and new treatment facilities added.

TABLE 53

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

BINGHAMTON UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 30.0 | 38.8 | 52.3 | 73.1 |
| Present Capability (mgd) | 93.0 | 93.0 | 93.0 | 93.0 |
| Deficit (mgd) | -- | -- | -- | -- |

## DESIRABILITY FOR REGIONALIZATION

The three major water systems have recognized the desirability of regionalization, because connections now exist among them for use in emergencies. Binghamton also has made emergency connections with some of the smaller utilities.

The location of some of the outlying communities presents a problem for their water supply. They do not have supply sources within their own boundaries, and they are at too great a distance from the available UMA resources to make the construction of transmission mains for an independent supply feasible. Therefore, the only alternative for these communities is to obtain water from the existing utilities within the UMA.

Consequently, regionalization is not merely desirable; it is essential. The only available water supply is from the Susquehanna River and the ground water aquifers which are in close proximity to it.

## DEVELOPMENT ALTERNATIVES

Available sources of water for the Binghamton UMA include the Susquehanna River and the ground water aquifers in close proximity to the river. Direct withdrawal of water from the Susquehanna by the city of Binghamton in the mid 1960's was only slightly less than the amount obtained from wells by other communities downstream. No reservoir sites in the immediate vicinity of Binghamton exist.

In its Susquehanna River Basin Study, the U.S. Army Corps of Engineers proposed, as a potential water supply source, the Charlotte Creek Project at the Davenport Center site, about 5 miles upstream of Oneonta. This multi-purpose project, however, appears to be too far from the Binghamton UMA for use as a source, at least within the time frame of this study.

Continued direct withdrawals from the Susquehanna River in the vicinity of Binghamton may at some future time require augmentation of the river to meet the area's demands. If this be the case, or if the demands as projected in the present study are found to be understated, then consideration of low-flow augmentation from the Charlotte Creek Project would be advisable.

Increased well field development might also require low-flow augmentation. Johnson City and Endicott, both downstream of Binghamton, rely on wells for their water supply. Large drafts over extended periods from wells located up to one-half mile from the Susquehanna River could reduce its low-flow downstream. The record minimum at the Vestal gage was 230 cfs, or about 149 mgd in September of 1964. A draft of 41 mgd, equal to the capacity of the existing wells in the vicinity of Endicott (see Figure 52), may be expected to influence a flow as low as the record, if a severe drought were to occur in the future.

Additional water supply does not appear to be a problem within the Binghamton UMA, because an excess of 63 mgd of water is currently available from already developed sources, and the existing capacity is more than sufficient for the needs of the area for the next fifty years.

The communities within the UMA must plan and coordinate an effective system of distributing water. However, additional distribution mains must be constructed to convey the water from the aquifers in close proximity to the Susquehanna River to the expanding urban areas and industrial complexes. The establishment of a single water management authority, which would represent the components of the entire UMA, might be the most efficient body to assist in the development of an integrated water supply system.

## CONCLUSIONS

The systems currently operating within the UMA are adequate to meet the present demands, and the availability of existing water resources is more than enough until the year 2020. However, the resources must be developed and utilized in the most effective manner if the growth potential of the area is to be realized. Construction of distribution and treatment facilities will be needed along with the renovation of many of the existing utilities.

The Binghamton UMA lends itself most favorably to regionalization as a means of satisfying its growing water demands.

By interconnection of existing water systems, and by intermunicipal cooperation within the UMA, an overall water supply agency could be established, to administer and implement the necessary construction programs which would insure the adequate distribution of water throughout the UMA.

# CHAPTER 15. ELMIRA

The Elmira Urban Metropolitan Area is located in the south central portion of New York State in the Chemung River Valley. Urban centers along the Chemung River and its major tributaries, from Steuben to Chemung, have accomodated the major population and industrial concentrations. The UMA that is expected to evolve by the year 2020 covers an area of approximately 125 square miles. It is shown on Figure 44; its components include:

<u>Chemung County</u>

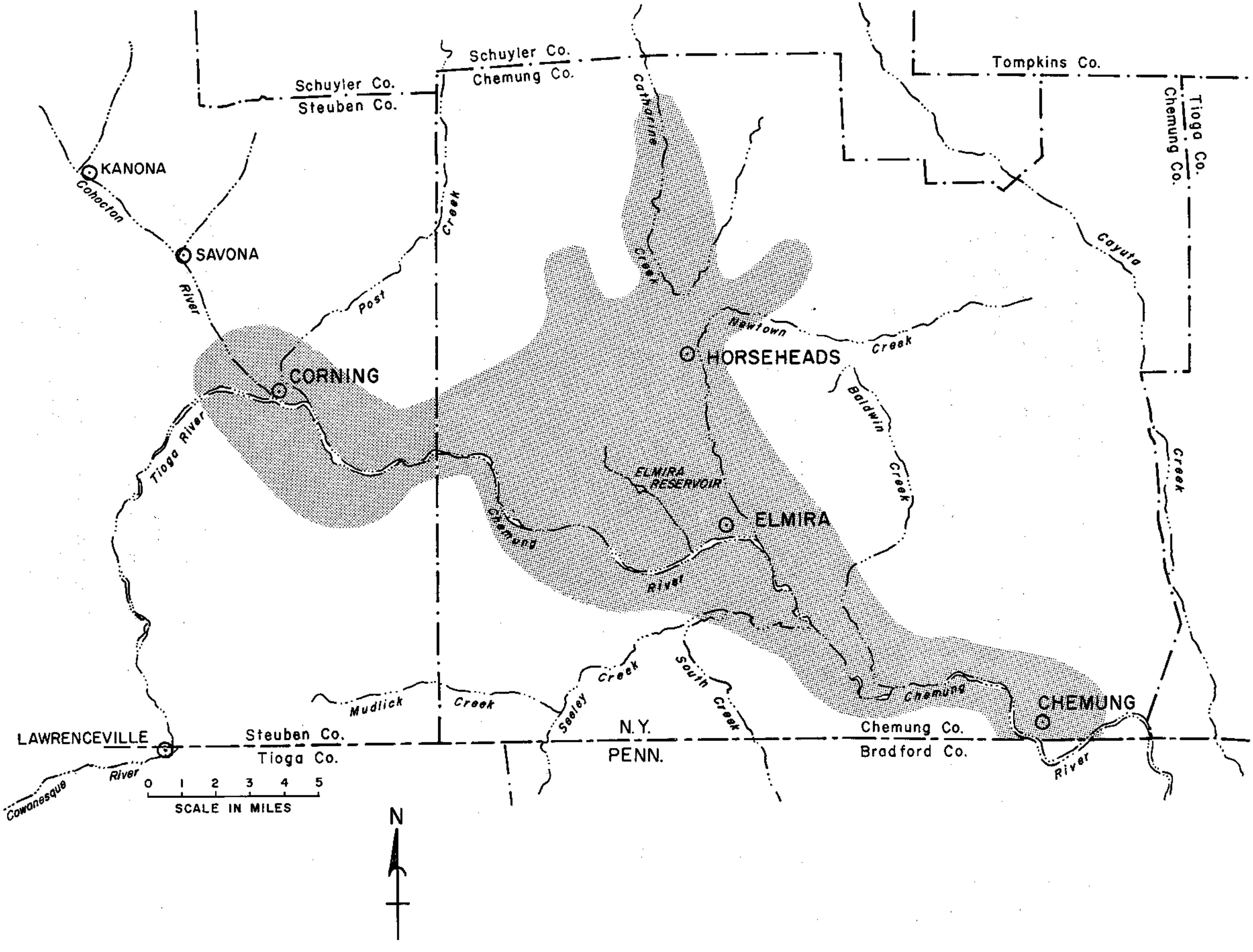
Ashland town (part)
  Wellsburg village
Baldwin town
Big Flats town
  Big Flats (u)
  Catlin town
  Chemung town
  Elmira city
Elmira town
  Elmira Heights village (part)
  West Elmira (u)
Erin town (part)
Horseheads town (part)
  Elmira Heights North (u)
  Elmira Heights village (part)
  Horseheads village
  Slabtown
Southport town (part)
  Southport (u)
Van Etten town
  Van Etten village
Veteran town (part)
  Millport village

<u>Steuben County</u>

Corning city
Corning town (part)
  Riverside village
  South Corning village

The climate of the area is classified as continental: the average temperature is about 49$^{o}$F, with extreme temperatures ranging from -24$^{o}$F and 107$^{o}$F. Average precipitation is 34 inches, with an average runoff of about 14 inches.

The area is quite hilly, except for the portion lying in the Chemung River Valley. Elevations may be between 900 to




ELMIRA UMA

FIGURE 44

1,000 feet above sea level in the valley, to over 1,700 feet at the summits of many of the steep hills in the UMA. The Chemung River and its two principal tributaries, Newton and Seeley Creeks, drain most of the area. The Chemung eventually empties into the Susquehanna River.

The present urban and industrial development is stretched along the Chemung River Valley, and includes the area between the cities of Corning and Elmira. Primary industries include food processing; manufacture of machinery; electronic and transportation equipment; fabricated metal; and clay, stone, and glass products. A good transportation network, including state highways, rail, and air service, provides easy access to the east coast and Great Lakes markets.

## POPULATION

The principal centers of population include the cities of Corning and Elmira, and the village of Horseheads. According to the 1970 census, these three municipalities had an aggregate population of more than 63,000, or more than one-half of the entire UMA population. Both Elmira and Corning have declined in population during the past decade, but most of the surrounding towns and villages have experienced slight to moderate increases in population, illustrating the trend toward suburbanization. Projections indicate that the Elmira UMA will almost double in population during the fifty-year study period. Population and density figures are shown in Table 54.

TABLE 54

POPULATION DATA

ELMIRA UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 116.8 | 117.9 | 135.0 | 184.5 | 227.2 |
| Population per square mile | 935 | 945 | 1,080 | 1,475 | 1,820 |

TABLE 55

WATER USAGE

ELMIRA UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 9.7 | 15.8 | 24.4 | 34.6 |
| Publicly-supplied industrial | 3.0 | 10.0 | 20.0 | 32.0 |
| TOTAL M & I | 12.7 | 25.8 | 44.4 | 66.6 |
| Publicly-supplied industrial | 3.0 | 10.0 | 20.0 | 32.0 |
| Self-supplied industrial | 8.0 | 8.0 | 8.0 | 8.0 |
| TOTAL INDUSTRIAL | 11.0 | 18.0 | 28.0 | 40.0 |
| Water Use (gcd) (Based on M & I) | 132.3 | 191.0 | 240.7 | 293.1 |

POPULATION AND M&I WATER USE
ELMIRA UMA

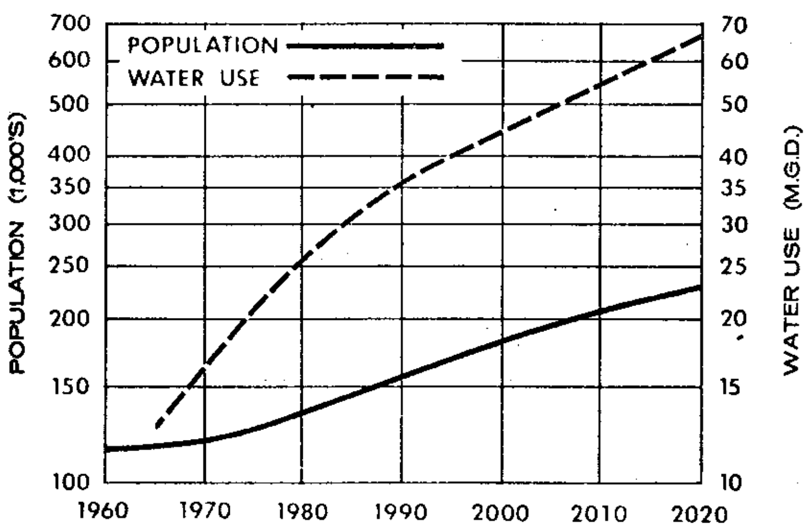



FIGURE 45

## WATER USAGE

Available data indicate that about 96,000 people were served by large and small water systems throughout the UMA during the mid 1960's. The average publicly supplied municipal and industrial water was about 12 mgd. By the year 2020, the UMA will require about 67 mgd to satisfy the municipal and industrial demands, or an increase of almost 6 times greater than the present M & I requirements.

The projections for water usage are shown in Table 55, while Figure 45 depicts graphically the trends in population and water requirements.

## KNOWN WATER SUPPLIES

### Summary

Several systems provide water within the UMA, and three, owned and operated by Corning, Elmira and the village of Horseheads are major suppliers. The largest of these systems is the Elmira Water Board, which serves a population exceeding 71,000, both within the city limits, and to a large portion of the developed areas outside and contiguous to the city.

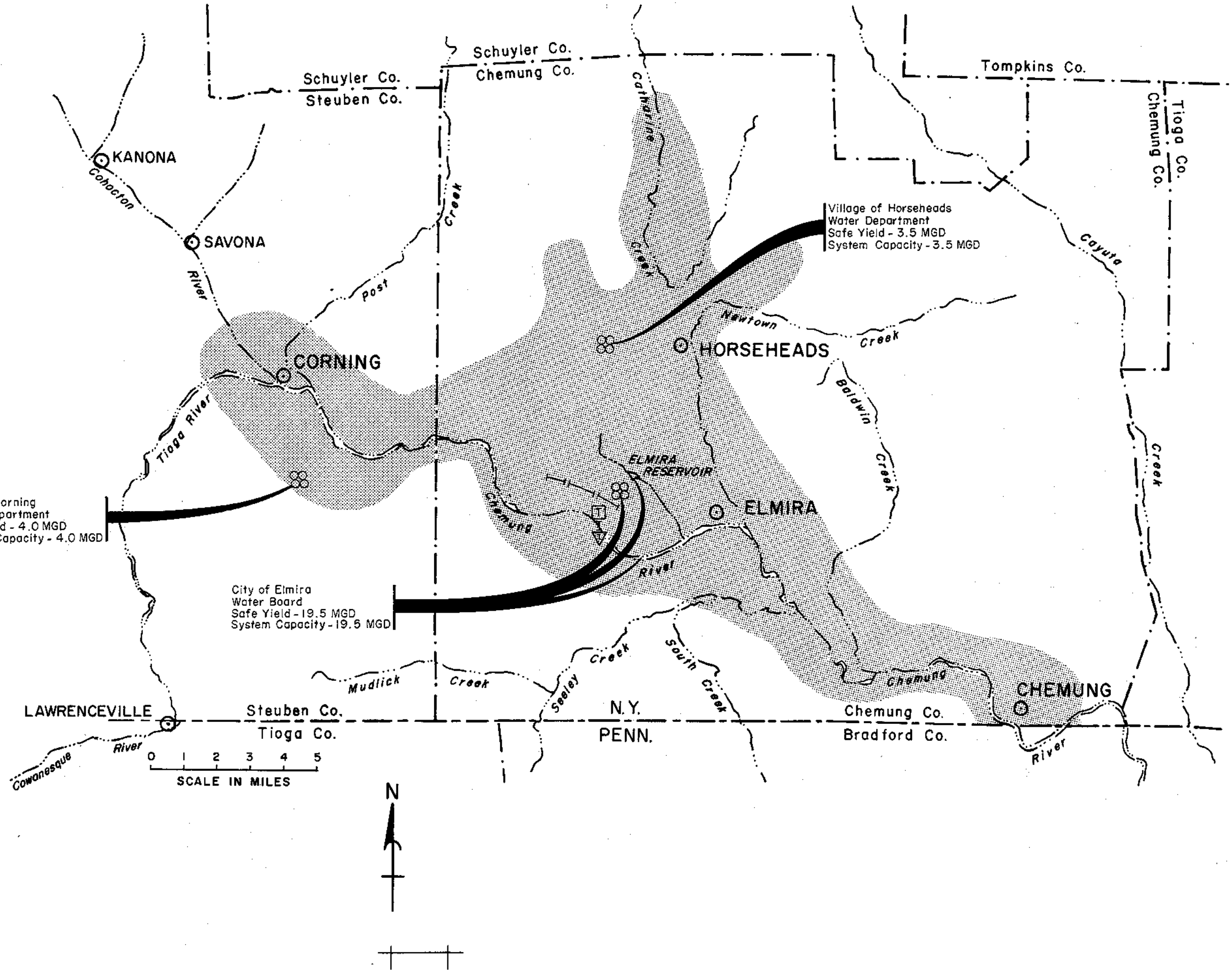
Figure 46 shows the major existing water supply systems within the UMA, and Table 56 contains data essential to each.

TABLE 56

KNOWN WATER SUPPLIES

ELMIRA UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| City of Corning Water Department | 17,000 | 2.5 | Ground Water Wells | | 4.0 | -- | N/A | 4.0 |
| City of Elmira Water Board | 71,000 | 8.0 | Surface Reservoirs | Elmira Reservoir | 2.0 | -- | -- | 19.5 |
| | | | | Chemung River | 12.0 | 12.0 | N/A | -- |
| | | | Ground Water Wells | | 5.5 | -- | -- | -- |
| Village of Horseheads Water Department | 8,000 | 2.2 | Ground Water Wells | | 3.5 | -- | N/A | 3.5 |




KNOWN WATER SUPPLIES
ELMIRA UMA

FIGURE 46

Future Adequacy

The developed source capacity of 27 mgd would be sufficient to meet the expected demand by the year 1980, as shown on Table 57 below, if it were entirely distributable throughout the UMA. However, most of the available water supply is concentrated in the city of Elmira; the other communities within the UMA have just enough water sources presently developed to keep abreast of their demands.

TABLE 57

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

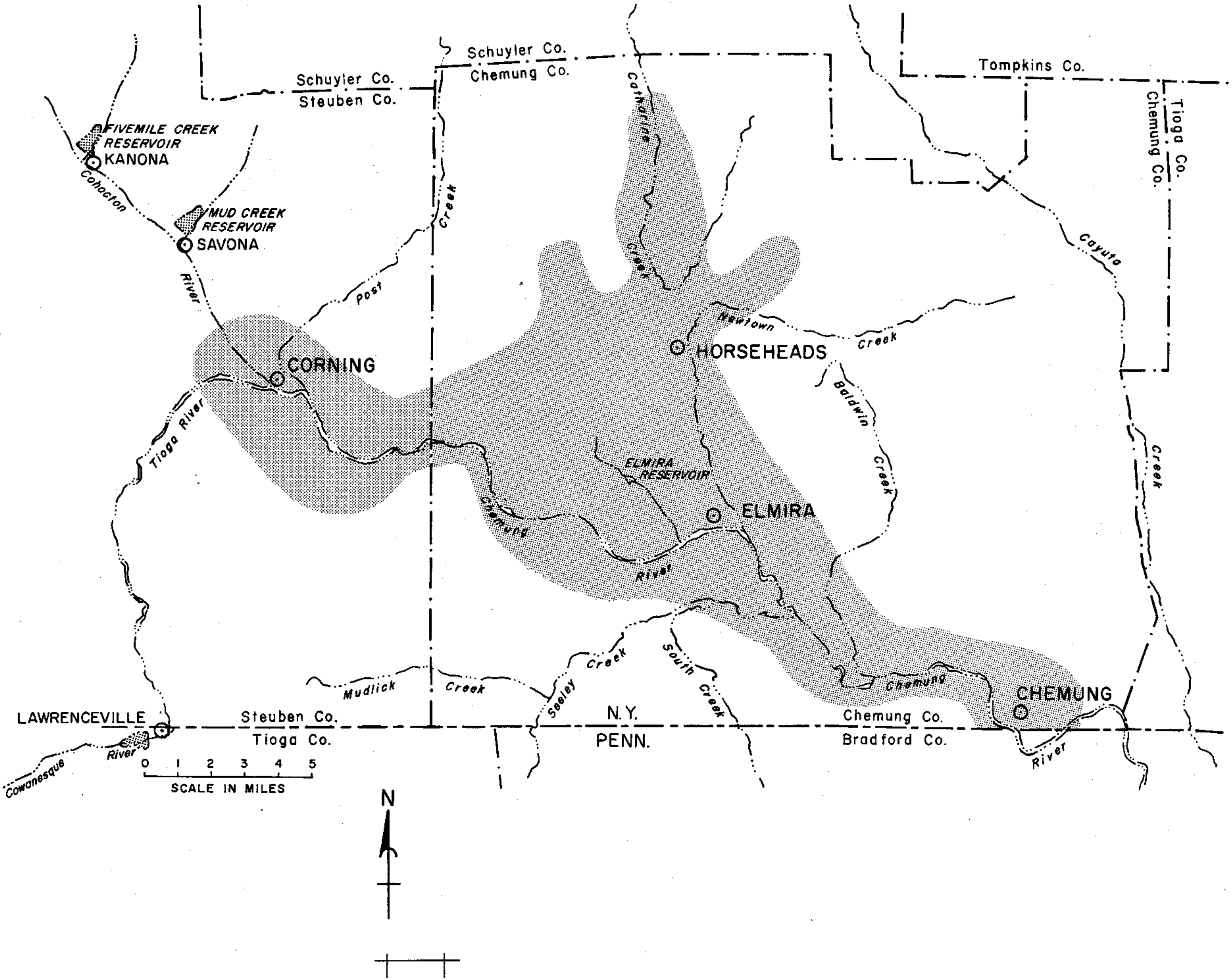
ELMIRA UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 12.0 | 25.8 | 44.4 | 66.6 |
| Present Capability (mgd) | 27.0 | 27.0 | 27.0 | 27.0 |
| Deficit (mgd) | -- | -- | 17.4 | 39.6 |

## DESIRABILITY FOR REGIONALIZATION

In a broad sense, regionalization already exists within the Elmira UMA, since the Elmira Board of Water provides service to 68 percent of the total population of Chemung County, either residing within the city or in areas adjacent and contiguous to it.

As the population expands to areas along the Chemung River Valley between Corning and Southport, it will become increasingly desirable to utilize the talents and facilities of the existing water supply agencies to provide water to the newly-developing areas. Even more desirable would be the establishment of a collective management, responsible for the planning, administration, and distribution of available water resources.




**POTENTIAL RESERVOIR SITES**
**ELMIRA UMA**
**FIGURE 47**

## DEVELOPMENT ALTERNATIVES

Because of the topography and location of the area and relatively small yield obtainable from any one or combination of potential reservoir sites, only two opportunities are reasonable to meet the future demands of the UMA: either drawing and treating water from the Chemung River, or drilling additional wells.

The city of Elmira presently treats approximately 12 mgd of water from an intake on the Chemung River. The remaining communities for the most part, depend on ground water aquifers for their water supply. Until such time as action is taken to build the necessary impoundment sites upstream to augment the flow in the river, dependable yield from the Chemung River is limited to its natural low-flow of 35 mgd (under severe drought conditions).

The Susquehanna Coordinating Committee has proposed two major multi-purpose dams and reservoirs on the Cohocton River, to prevent severe drought conditions from affecting water supply as well as water quality in Elmira. Fivemile Creek Project near Kanona, having a 1,150-acre lake, and Mud Creek Project near Savona, with a 2,050-acre lake, would be built to augment flows, thus permitting Elmira to increase its withdrawals of water.

The Coordinating Committee also proposed the reallocation of 45,000 acre feet of flood control storage, in the authorized Cowanesque Reservoir Project at Lawrenceville, Tioga County, Pennsylvania, for low flow augmentation around 1990. For the period after 1990, the Fivemile Creek Project would be utilized to meet Elmira's needs, and then the Mud Creek Project. (See Fig. 47.)

Future source development will depend primarily upon the excellent ground water aquifers along the Chemung River, which has an estimated potential yield of between 53 and 76 mgd. However, large drafts over extended periods from wells in the immediate vicinity of the river could reduce the low-flows in the Chemung River, if augmentation is not provided.

## CONCLUSIONS

Gross deficits of 17.4 and 39.6 mgd are projected for 2000 and 2020, respectively, in the Elmira UMA. The existing water supplies and current firm plans are not sufficient to preclude the deficits. Either development of additional ground water supplies or direct pumping of raw water from the Chemung River will be required to prevent the 2000 deficit from materializing; and additional treatment capacity will be required to utilize the raw water from the Chemung.

Further ground water development may be adequate to meet the projected demands of the UMA through the year 2020. But augmentation from a storage reservoir on the tributaries of the Chemung would be required to provide the necessary quantities of surface water. Because of the topography, impoundment sites are not favorable to construction on the Chemung River. Three properly phased upstream impoundments, two on the Cohocton River and one on the Cowanesque River, would provide necessary low-flow augmentation, and thus would guard against the failure of quality or quantity of the ground water sources.

To insure the proper development and distribution of additional water supply, a single managerial agency should be established to coordinate the development of future water supply, and to arrange for treatment, transmission, and interconnections.

# CHAPTER 16. SCRANTON - WILKES-BARRE

The Scranton-Wilkes-Barre Urban Metropolitan Area is located in northeastern Pennsylvania, lying along the Lackawanna and Susquehanna River Valley, through Lackawanna and Luzerne Counties. The city of Hazelton is a part of the Wilkes-Barre Hazelton SMSA, but because it is separated from Wilkes-Barre by Nescopeck Mountain, it is not even included as part of the UMAs identified herein.

Urbanized areas are located between the cities of Scranton and Wilkes-Barre. The UMA that is expected to evolve by the year 2020 will cover an area of approximately 160 square miles. It is shown on Figure 48, and those components expected to be either partially or totally within the UMA boundaries follow:

Lackawanna County

Abington borough
Archbald borough
Carbondale city
Carbondale township
Clarks Green borough
Clarks Summit borough
Dalton borough
Dickson City borough
Dunmore borough
Elmhurst township
Fell township
Glenburn township
Jermyn borough
Jessup borough
Mayfield borough
Moosic borough
Moscow borough
Old Forge borough
Olymphant borough
Roaring Brook township
Scranton city
South Abington township
Spring Brook township
Taylor borough
Throop borough
Vandling borough

Luzerne County

Ashley borough
Avoca borough
Cortdale borough
Dallas borough
Dupont borough
Duryea borough
Edwardsville borough
Exeter borough
Fairview township
Forty Fort borough
Hanover township
Hugestown borough
Hunlock township
Jackson township
Jenkins township
Kingston borough
Kingston township
Laflin borough
Larksville borough
Laurel Run borough
Luzerne borough
Nanticoke city
Newport township
  Glen Lyons (u)
Nuangola borough
Pittston city

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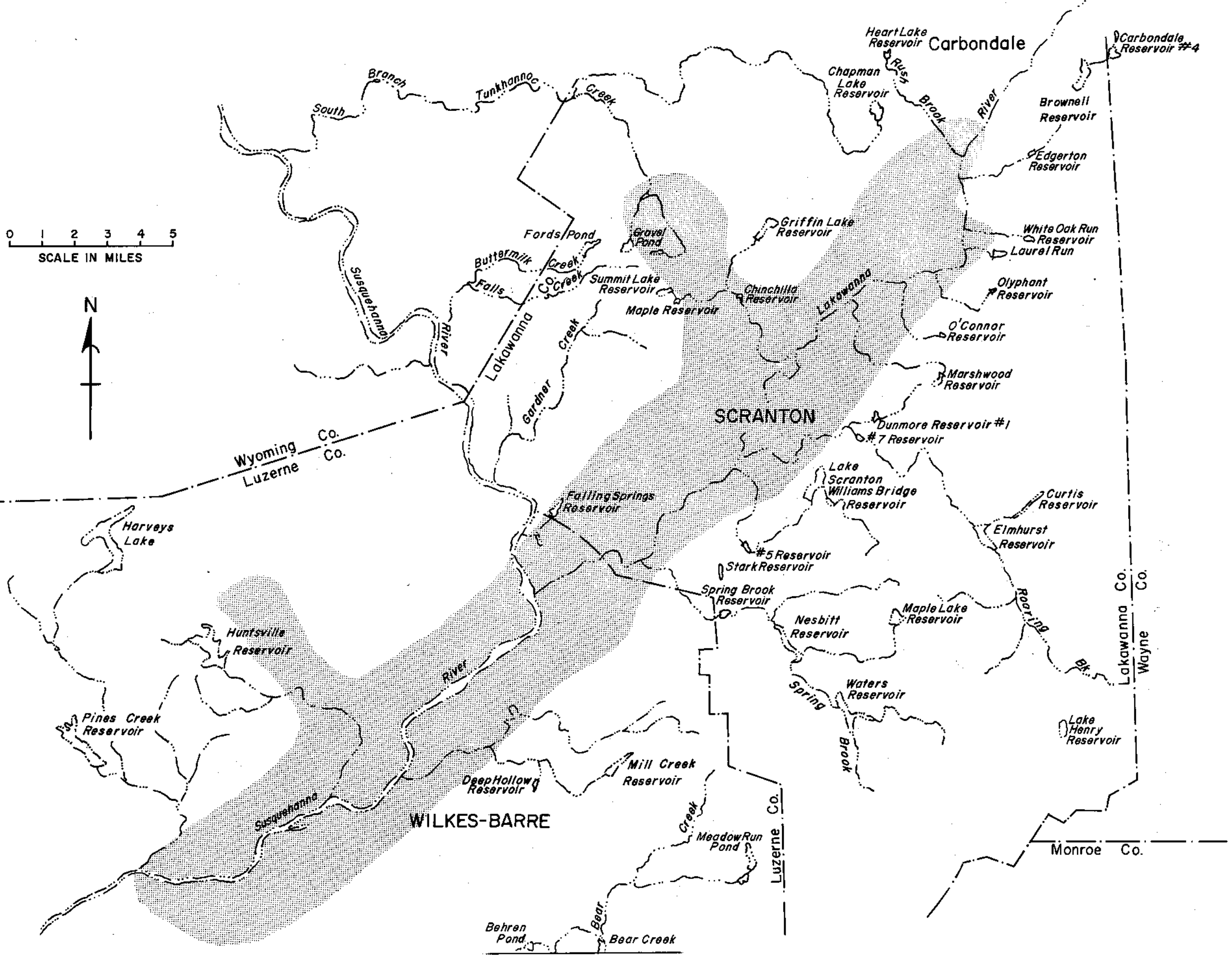


180

SCRANTON-WILKES-BARRE UMA

FIGURE 48

Luzerne County (Con't)

Pittston township
Plains township
  Plains (u)
Plymouth borough
Plymouth township
Pringle borough
Rice township
Sugar Notch borough
Swoyersville borough
Warrior Run borough
West Pittston borough
West Wyoming borough
Wilkes-Barre city
Wilkes-Barre township
Wright township
Wyoming borough
Yatesville borough

The climate of the area is generally classified as continental, with a considerable variance of temperatures between the warmest and coldest months. The average temperature is 50°F, with extremes recorded of -19° and 103°F. The average precipitation is approximately 37 inches, and runoff averages 22 inches.

The Lackawanna and Susquehanna River Valleys, bordered on both sides by steep mountains, dominate the area. In the natural corridor from Nanticoke City to Archbald borough, elevations rise gradually from 500 feet above sea level to 900 feet. The mountain ridges bordering the corridor, however, rise steeply to altitudes of 1,000 to 1,500 feet.

The area's topography has encouraged concentration of the primary economic and industrial development in the valley strip between Scranton and Wilkes-Barre. Primary industries include food, apparel and other textiles, furniture and fixtures, paper and allied products, printing and publishing, rubber and plastics, machinery, except electrical, transportation equipment, and miscellaneous manufacturing industries.

The UMA has an excellent transportation network, including interstate highways, rail service, and air service that provide easy access to the east coast and midwest of the United States.

## POPULATION

The present UMA is about the same as the urban area which existed in the 1930's. Because of constant slackening of the hard-coal industry, and the resultant loss of jobs, the UMA has experienced a steady decline in population. However, the rate of decline has almost ceased, and it is expected that in the years to come, the area will gain in population as new industry and opportunities draw people to the area. Projections indicate that by the year 2020, the population will be somewhat greater than that of 1930. Population and density figures are shown in Table 58.

TABLE 58

POPULATION DATA

SCRANTON-WILKES-BARRE UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 476.2 | 462.3 | 497.6 | 603.9 | 692.2 |
| Population per square mile | 2,975 | 2,900 | 3,100 | 3,775 | 4,325 |

## WATER USAGE

Available data indicate that in the mid 1960's, about 460,000 people were served by water systems throughout the UMA. The average publicly supplied municipal and industrial demand was about 88 mgd at that time.

It is estimated that by the year 2020, the UMA will require 201 mgd to satisfy municipal and industrial water requirements, an increase of more than 130 percent over the mid 1960's M & I demand.

The projections for water usage for the UMA are shown in Table 59, and Figure 49 depicts graphically the trends in population and M & I.

TABLE 59

WATER USAGE

SCRANTON-WILKES-BARRE UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 58.0 | 77.4 | 108.3 | 143.2 |
| Publicly-supplied industrial | 30.0 | 33.0 | 43.0 | 57.8 |
| TOTAL M & I | 88.0 | 110.4 | 151.3 | 201.0 |
| Publicly-supplied industrial | 30.0 | 33.0 | 43.0 | 57.8 |
| Self-supplied industrial | 12.0 | 12.0 | 12.0 | 12.0 |
| TOTAL INDUSTRIAL | 42.0 | 45.0 | 55.0 | 69.8 |
| Water Use (gcd) (Based on M & I) | 191.0 | 222.0 | 251.0 | 290.0 |

POPULATION AND M&I WATER USE

SCRANTON-WILKES BARRE UMA

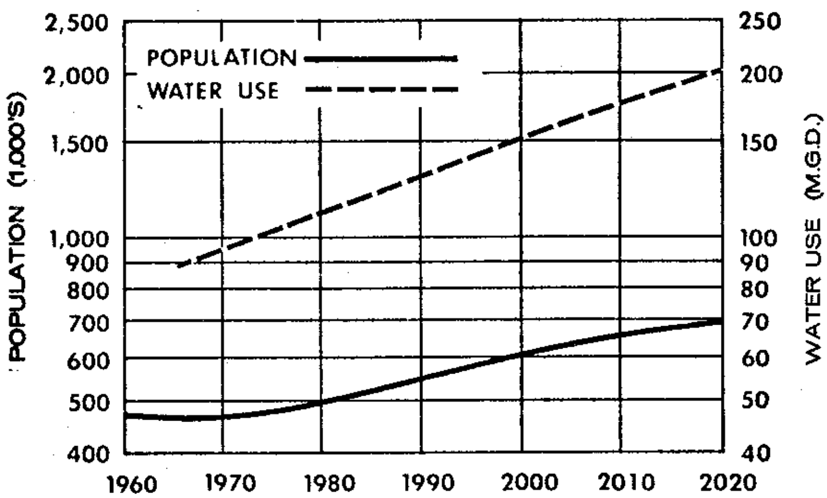


FIGURE 49

## KNOWN WATER SUPPLIES

### Summary

Several water supply systems, one of which is a major utility, provides water throughout most of the UMA.

The Pennsylvania Gas and Water Company (PG&W), established on what amounts to be a regional basis, is the largest water-supply utility within the UMA. The PG&W has several stream intakes, and more than 30 reservoirs, with a combined storage capacity of 19.6 billion gallons scattered throughout the watersheds of the Lackawanna and Susquehanna Rivers. In addition to surface water, the PG&W has 21 wells having a reported combined yield in excess of 2 mgd. The PG&W company provides most of the water service to the communities within the UMA. With all of its resources, the PG&W can supply up to 140 mgd throughout its extensive service area.

Two smaller water companies serve the remaining parts of the UMA within Lackawanna County: The Clarks Summit Water Company (CSWC) and the Moscow Water Company (MWC). The CSWC obtains its supply from impounded surface waters and several deep wells. Total delivery capacity is rated at 1 mgd. In the past, the CSWC had to purchase some of its water from the PG&W, but this is no longer necessary.

The MWC obtains its supply of water from a small, spring-fed reservoir capable of yielding about 0.2 mgd. The system serves most of Moscow borough.

In Luzerne County, the only water supplier other than the PG&W to provide water to areas within the UMA, is the Dallas Water Company (DWC). This utility, whose source of supply is 9 wells with a safe yield of 1.9 mgd, supplies the Dallas borough and parts of Dallas township.

Figure 50 shows the one major water system and these three of the smaller systems in the UMA, and Table 60 contains data essential to each.

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**KNOWN WATER SUPPLIES**
**SCRANTON-WILKES-BARRE UMA**

**FIGURE 50**

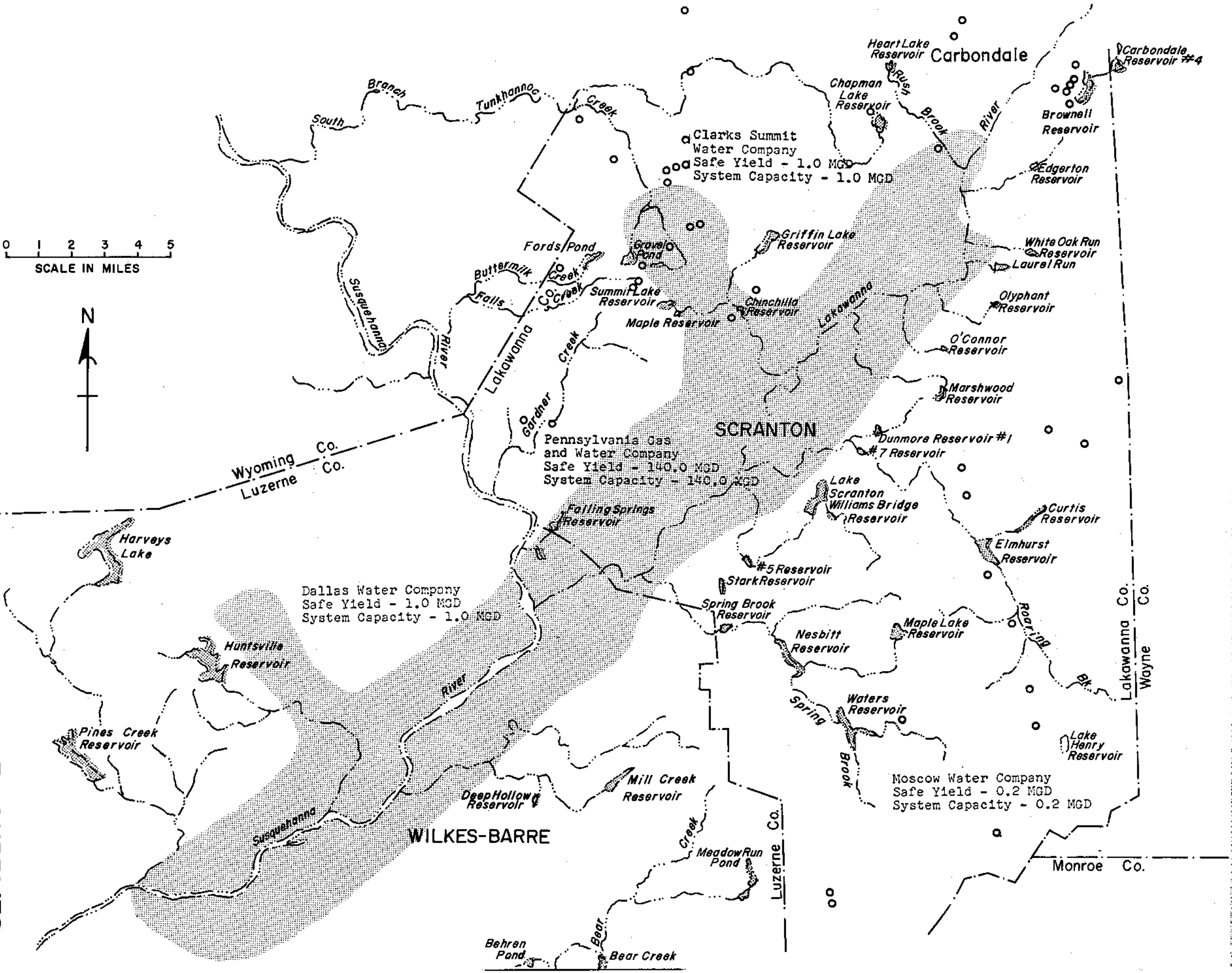


TABLE 60

KNOWN WATER SUPPLIES

SCRANTON - WILKES-BARRE UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Clarks Summit Water Company | 5,100 | 1.0 | Surface | Unnamed Reservoir | | | | |
| | | | Ground Water Wells - 5 | | 1.0 | -- | N/A | 1.0 |
| Dallas Water Company | 4,000 | 0.5 | Ground Water Wells - 9 | | 1.2 | -- | N/A | 1.0 |
| Moscow Water Company | 900 | 0.06 | Springfed Surface Reservoir | | 0.2 | -- | N/A | 0.2 |
| Pennsylvania Gas & Water Co. | 442,000 | 87.0 | Surface Reservoirs - 39 | | 140.0 | -- | N/A | 140.0 |
| | | | Ground Water Wells - 21 | | | | | |

## Future Adequacy

The combined resources of the four water supply systems amounts to 142.2 mgd. By including other smaller water systems, the total safe yield of the UMA, is estimated to be 145 mgd. However, as shown on Table 61, this amount of water is insufficient to meet projected UMA requirements prior to the year 2000.

TABLE 61

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

SCRANTON-WILKES-BARRE UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 88.0 | 110.4 | 151.3 | 201.0 |
| Present Capacity (mgd) | 145.0 | 145.0 | 145.0 | 145.0 |
| Deficit (mgd) | -- | -- | 6.3 | 56.0 |

## DESIRABILITY FOR REGIONALIZATION

The Scranton-Wilkes-Barre area has enjoyed the benefits of a regional water supply system for a number of years. The PG&W has maintained numerous reservoirs and watersheds from which it has supplied the majority of the UMA population, as well as other parts of Lackawanna and Luzerne Counties, and portions of Susquehanna and Wayne Counties. As the population grows and development attracts new industry, the PG&W will be able to supply the needed water, because distribution and transmission mains are already in place that will serve as a framework for expansion.

In the past, a drought forced the Clarks Summit Water Company to purchase water from the PG&W. Because of their present limitations in both resources and facilities, the MWC and DWC would have considerable difficulty in supplying water if shortages, through drought or well contamination, should occur at some future date. Recognition of the limitations argues strongly for interconnection with the PG&W.

## DEVELOPMENT ALTERNATIVES

To meet the projected deficit of the year 2020, the PG&W should undertake a program to prepare for adequacy of supply: renovating and expanding reservoirs where needed; upgrading and restoring existing transmission and distribution mains; locating new reservoir sites on the tributaries of the Susquehanna or Lackawanna River; and developing additional ground water resources.

The diversion of water from the Lackawanna and Susquehanna Rivers is a possibility for water supply. Of course, substantial treatment of the source would be necessary; but as the environment of the area and of the county as a whole is improved, perhaps the quality of the river water will improve as well, thereby requiring less extensive treatment.

Another alternative for water supply that deserves further exploration is the sealing of abandoned coal mines and caverns to allow them to fill with water, thus being converted into huge underground reservoirs. The difficulties of this alternative are considerable: the sites must be chosen carefully, because of possible health and safety hazards; past experience has shown that land subsidence occurs in the vicinity of abandoned coal mines; acid mine water could contaminate the reservoirs; and the water obtained from such sources would, of course, require treatment prior to use. Nevertheless, this alternative may prove to be a more economical solution to the water supply problem than constructing far - distant reservoirs and expensive transmission facilities.

## CONCLUSIONS

Although a deficit of 56 mgd by the year 2020 is projected, it is unlikely that it will ever materialize. The area has many potential locations which can be developed as reservoirs to supply additional water. Also, supply from ground water is pointed out as a favorable geologic opportunity. The sealing and filling of old mines with ground water offers an opportunity that could provide dual benefits, providing underground storage reservoirs and disposing of abandoned open mines. However, safety and health hazards must be carefully evaluated before this option is taken.

The PG&W company is the regional system for the UMA and will more than likely continue in this capacity. It appears that the water supply situation within the UMA is in very capable hands, and that no major deficits should be experienced within the next fifty years.

# CHAPTER 17. WILLIAMSPORT

The Williamsport Urban Metropolitan Area is located in the northcentral part of the Commonwealth of Pennsylvania. It lies along the West Branch Susquehanna River that flows through Lycoming County in an easterly direction. The UMA that is expected to evolve by the year 2020, shown on Figure , covers an area of approximately 110 square miles. The components that will be totally or partially within the UMA include:

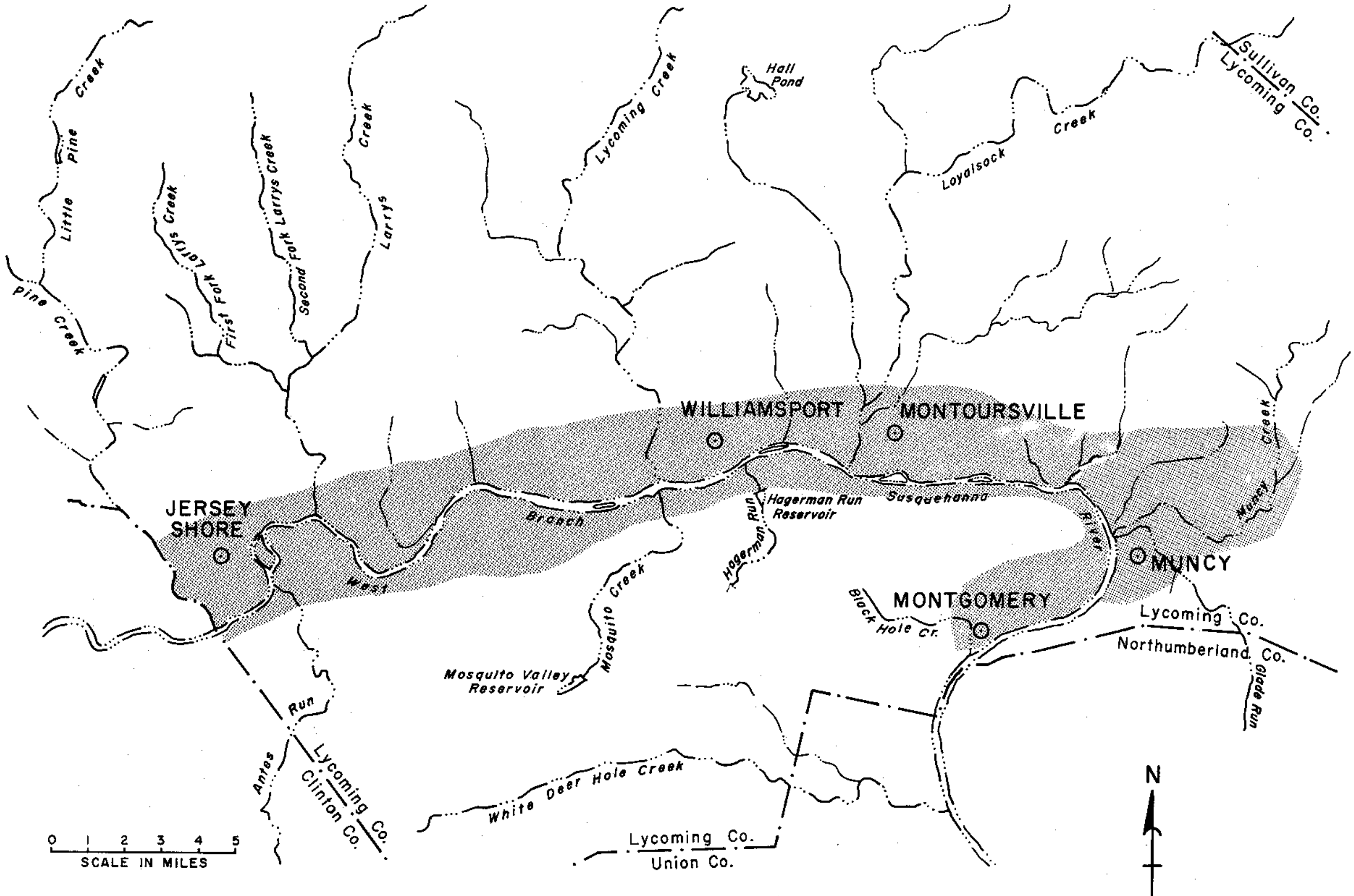
<u>Lycoming County</u>

| | |
|---|---|
| Armstrong township (part) | Muncy borough |
| Bastress township (part) | Muncy Creek township (part) |
| Clinton township (part) | Muncy township (part) |
| Duboistown borough | Nippenose township |
| Fairfield township (part) | Old Lycoming township |
| Hughesville borough | Garden View (u) |
| Jersey Shore borough | Platt township |
| Loyalsock township (part) | Porter township |
| East Faxon (u) | Salladasburg borough |
| Faxon (u) | South Williamsport borough |
| Lycoming township (part) | Susquehanna township |
| Mifflin township (part) | Williamsport city |
| Montgomery borough (part) | Woodward city |
| Montoursville borough | |

The climate of the area is generally classified as continental. The mean temperature at Williamsport is about 51°F, with extreme temperatures ranging from -15°F to 102°F. Precipitation averages 40 inches, with about 60 inches of snow per year. Average runoff is 21 inches.

The West Branch Susquehanna River is the dominant topographic feature of the area. Rough, mountainous terrain and deep, narrow valleys prevail throughout the northern section of the county. Steep mountain ridges parallel the West Branch Susquehanna along the southern portion of the county.

Economic and industrial development at present is centered in the city of Williamsport. Primary industries include food, apparel and textiles, lumber and wood, printing and publishing, fabricated metals, machinery, except electrical, and electrical equipment and supplies.




WILLIAMSPORT UMA
FIGURE 51

Anderson-Nichols & Co., Inc.

Although there are no interstate highways within the UMA, the area is only a short distance from Interstate 80, to the south. U.S. Routes 15 and 220 traverse the area in a north-south and northeast-southwest direction, respectively. Rail service is provided by the Penn Central Railroad and the Reading Railway System. Air transportation is available at the Williamsport Airport, located in Montoursville.

## POPULATION

The principal centers of population currently include the city of Williamsport, and the surrounding communities of Loyalsock township, Montoursville borough, and South Williamsport borough. The four municipalities had a combined population of more than 61,000, more than 60 percent of the entire UMA population, according to the 1970 census. The city of Williamsport has declined in population during the last ten years, as have most other older, more urban areas, because of the trend toward suburbanization. As a result, most of the other components of the UMA have increased in population during the same time period.

Projections indicate that the UMA will increase in population from 96,300 in 1970 to 133,100 in 2020, or by about 40 percent. Population and density figures for the UMA are shown in Table 62.

TABLE 62

POPULATION DATA

WILLIAMSPORT UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 94.9 | 96.3 | 109.6 | 121.1 | 133.1 |
| Population per square mile | 865 | 875 | 995 | 1100 | 1210 |

## WATER USAGE

Available data indicate that about 70,400 people were served by large and small water systems throughout the UMA during the mid 1960's. The average publicly supplied municipal and industrial demand was at that time about 10 mgd.

TABLE 63

WATER USAGE

WILLIAMSPORT UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 6.5 | 13.4 | 17.6 | 23.2 |
| Publicly-supplied industrial | 3.5 | 5.0 | 7.4 | 10.8 |
| TOTAL M & I | 10.0 | 18.4 | 25.0 | 34.0 |
| Publicly-supplied industrial | 3.5 | 5.0 | 7.4 | 10.8 |
| Self-supplied industrial | 5.0 | 5.0 | 5.0 | 5.0 |
| TOTAL INDUSTRIAL | 8.5 | 10.0 | 12.4 | 15.8 |
| Water Use (gcd) (Based on M & I) | 140.6 | 168.0 | 206.0 | 255.0 |

POPULATION AND M&I WATER USE

WILLIAMSPORT UMA

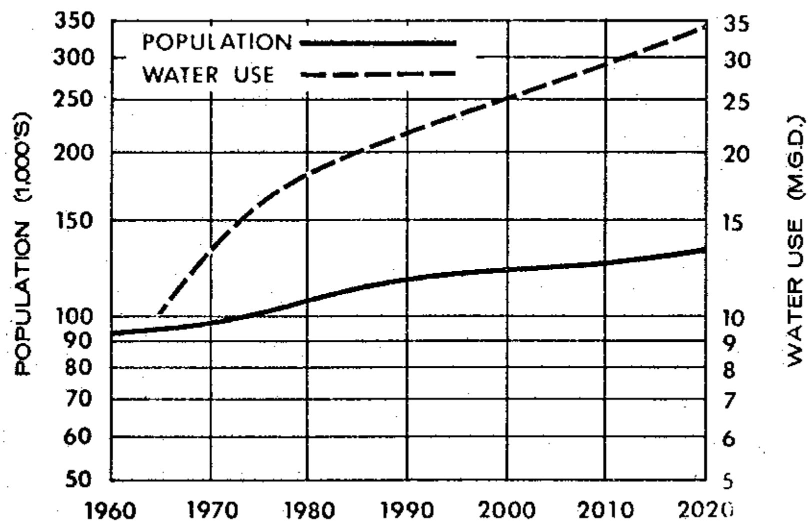



FIGURE 52

By the year 2020, the UMA will require about 34 mgd to satisfy its M & I demand, an increase of almost 200 percent over the present demand.

Projections for water usage are shown on Table 63 for the Williamsport UMA, and Figure 52 depicts graphically the projected population and water requirements.

## KNOWN WATER SUPPLIES

### Summary

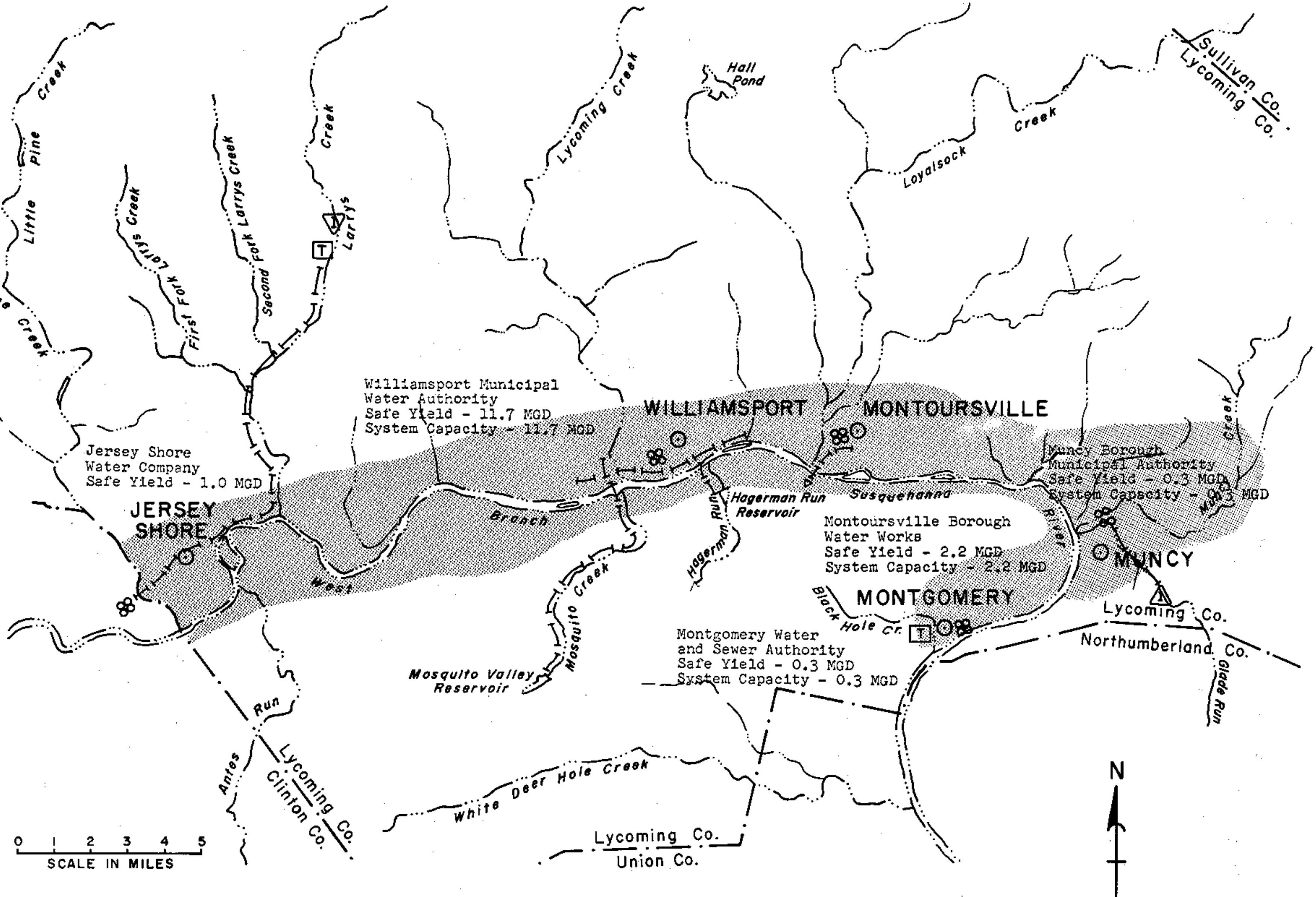
There are five principal water suppliers in Lycoming County that lie within the boundaries of the anticipated UMA. The largest supplier is the Williamsport Municipal Water Authority.

The Williamsport Municipal Water Authority obtains water from three surface reservoirs having a total storage capacity of 557 million gallons and a combined safe yield of 4.7 mgd, and from eight supplemental wells with a yield of approximately 7.0 mgd. Treatment consists of chlorination and floridation. The areas served by the Authority include Williamsport city, South Williamsport and Duboistown boroughs, and portions of Armstrong, Loyalsock and Old Lycoming townships.

The Muncy Borough Municipal Authority has one reservoir with a storage capacity of 2.3 million gallons, and five wells with a reported combined yield of 2.2 mgd. Treatment is chlorination; distribution is made to Muncy Borough, and to portions of Muncy and Muncy Creek townships.

The Montgomery Water and Sewer Authority water supply source is one reservoir having a storage capacity of 0.6 million gallons (estimated safe yield of 0.29 mgd); and two wells with a total yield of 0.01 mgd. Service is provided throughout Montgomery borough, after the water has been filtered and chlorinated.

Montoursville Borough Water Works provides water throughout the borough from three wells, with a reported total yield of 1.6 mgd; two reservoirs having a storage capacity of 0.9 million gallons; and two springs yielding 0.6 mgd. Treat-




KNOWN WATER SUPPLIES
WILLIAMSPORT UMA

FIGURE 53

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ment includes chlorination, and water softening for the spring water.

The Jersey Shore Water Company obtains water from three reservoirs having a total storage capacity of 3.6 million gallons, and from two wells with a reported yield of 0.7 mgd. Treatment consists of chlorination and filtration; distribution is to Jersey Shore and Salladasburg boroughs, Larryville and Antes Fort villages, and South Avis, located in Clinton County.

The five water supply systems collectively provided about 9.8 mgd of water to a population of over 70,000 in the mid 1960's. The largest, Williamsport Municipal Water Authority, supplied 7.0 mgd of water to a population of 51,000 at that same time.

Table 64 contains data pertinent to the five principal systems, and Figure 53 depicts them.

TABLE 64

KNOWN WATER SUPPLIES

WILLIAMSPORT UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Jersey Shore Water Company | 8,000 | 1.0 | Surface Reservoirs | Roaring Run Larry's Creek Pine Creek | 0.3 | | | 1.0 |
| | | | Ground Water Wells - 2 | | 0.7 | | | |
| Montgomery Water & Sewer Authority | 1,900 | 0.3 | Surface Reservoir | Black Hole Creek | 0.29 | | | 0.3 |
| | | | Ground Water Wells - 2 | | 0.01 | | | |
| Montoursville Borough Water Works | 6,000 | 0.9 | Surface Reservoir | | | | | |
| | | | Ground Water Springs - 2 | | 0.6 | | | 2.2 |
| | | | Wells - 3 | | 1.6 | | | |
| Muncy Borough | 4,500 | 0.6 | Surface Reservoir | Glade Run | | | | 2.2 |
| | | | Ground Water Wells - 5 | | 2.2 | | | |
| Williamsport Municipal Water Authority | 51,000 | 7.0 | Surface Reservoir | Mosquito Creek Hagerman's Run | 4.7 | | | 11.7 |
| | | | Ground Water Wells - 8 | | 7.0 | | | |

## Future Adequacy

The combined safe yield of existing surface and ground water resources of the Williamsport area amounts to a little more than 17 mgd. Therefore, as can be seen in Table 65, the UMA will experience a water deficit at some time around 1980.

TABLE 65

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

WILLIAMSPORT UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 10.0 | 18.4 | 25.0 | 34.0 |
| Present Capability (mgd) | 17.4 | 17.4 | 17.4 | 17.4 |
| Deficit (mgd) | -- | 1.0 | 7.6 | 16.6 |

## DESIRABILITY FOR REGIONALIZATION

Each major system operating within the Williamsport UMA is currently utilizing its water resources almost to full capacity. There are no interconnections known to exist between any of the systems; the only means of increasing the water supply availability, therefore, is either to develop new resources on an individual basis, or to make interconnections to draw upon the existing resources of the other systems, individually or collectively.

Many opportunities to develop surface or ground water reservoirs are available to meet the future needs of the UMA. A regional system under single management seems advantageous for integration of existing facilities and development of new supplies.

## DEVELOPMENT ALTERNATIVES

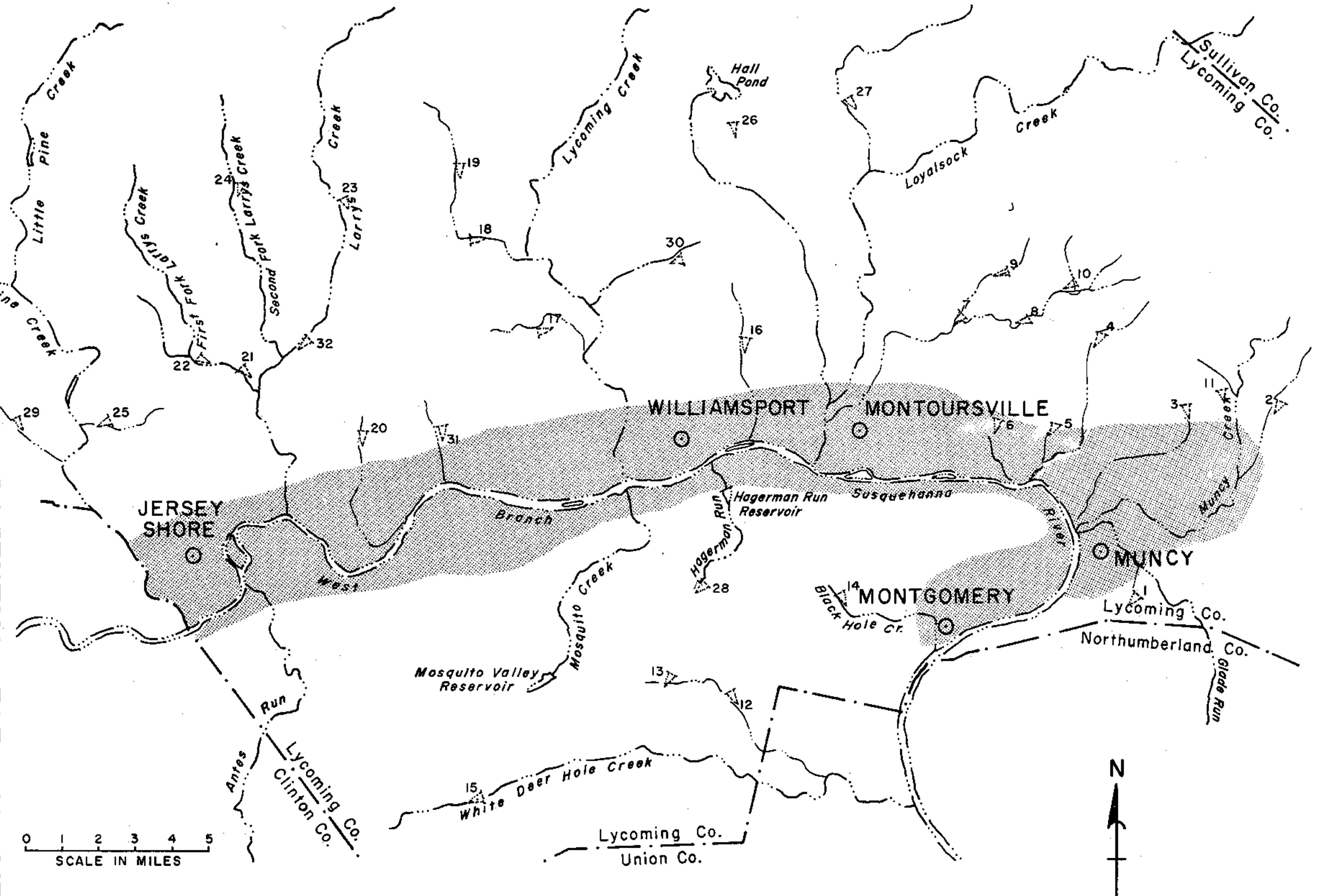
The Williamsport UMA has access to an abundance of water resources, both surface and ground water. There are more than 140 potential reservoir sites scattered throughout Lycoming County that have been identified by the Soil Conservation Service and/or the U.S. Army, Corps of Engineers. These could be developed for purposes of water supply, recreation, and flood control. Thirty-two such reservoir sites that are in close proximity to the UMA and potentially amenable for water supply development are shown on Figure 54, while Table 66 lists the available data pertinent to each.

TABLE 66

POTENTIAL RESERVOIR SITES

FOR WATER SUPPLY DEVELOPMENT

| Location Number | Name of Stream | Drainage Area Square Miles | Storage Capacity, MG |
|---|---|---|---|
| 1 | Glade Run | 4.8 | 1,232 |
| 2 | Gregs Run | 7.4 | 2,504 |
| 3 | Wolf Run | 2.6 | 469 |
| 4 | Carpenters Run | 2.7 | 293 |
| 5 | Margaret Run | 2.0 | 313 |
| 6 | Twin Run | 2.7 | 548 |
| 7 | Mill Creek | 18.1 | 1,506 |
| 8 | Mill Creek | 10.0 | 932 |
| 9 | Little Mill Creek | 4.0 | 195 |
| 10 | Mill Creek | 6.8 | 1,004 |
| 11 | Pine Run | 1.0 | 182 |
| 12 | Spring Creek | 11.5 | 958 |
| 13 | Spring Creek | 2.2 | 822 |
| 14 | Black Hole Creek | 3.0 | 78 |
| 15 | White Deer Hole | 12.5 | 730 |
| 16 | Millers Run | 3.0 | 730 |
| 17 | Beautys Run | 6.5 | 1,043 |
| 18 | Hoageland Run | 17.7 | 1,982 |
| 19 | Hoageland Run | 8.4 | 469 |
| 20 | Pine Run | 4.1 | 1,187 |
| 21 | First Fork Larry's Creek | 17.3 | 1,610 |
| 22 | First Fork Larry's Creek | 13.4 | 352 |




POTENTIAL RESERVOIR SITES
WILLIAMSPORT UMA

FIGURE 54

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TABLE 66 (Cont.)

POTENTIAL RESERVOIR SITES

FOR WATER SUPPLY DEVELOPMENT

| Location Number | Name of Stream | Drainage Area Square Miles | Storage Capacity, MG |
|---|---|---|---|
| 23 | Larry's Creek | 29.2 | 1,565 |
| 24 | Second Fork Larry's Creek | 16.3 | 626 |
| 25 | Tombs Run | 5.3 | 782 |
| 26 | Mill Creek | 7.9 | 6,872 |
| 27 | Wallis Run | 32.5 | 5,216 |
| 28 | Hageman Run | 1.8 | 391 |
| 29 | Gamble Run | 5.2 | 117 |
| 30* | Mill Creek | 5.7 | 82 |
| 31* | Quenshukeny Run | 7.8 | 313 |
| 32* | Larry's Creek | 34.4 | 2,645 |
| | Sub-Totals | 307.8 | 37,748 |

Other potential reservoir sites located within Lycoming County but not shown on Figure **54** because they are located outside of the figure boundaries:

| | | |
|---|---|---|
| Laurel Run Tributary | 2.3 | 551 |
| Little Muncy Creek | 61.6 | 3,130 |
| Little Muncy Creek | 46.7 | 5,085 |
| Sugar Run | 2.9 | 647 |
| Sugar Run | 5.9 | 587 |
| Grays Run | 14.7 | 548 |
| *Laurel Run | 8.7 | 260 |
| Sub-Totals | 142.8 | 10,808 |
| TOTAL | 450.6 | 48,808 |

* Identified in the Susquehanna River Basin Study as a Potential Reservoir site.

Ground water is available in varying degrees throughout most of the UMA. Large supplies of ground water, underlying the industrial areas of the UMA, have been exploited for yields -

from 50 to 300 gpm - at numerous places. Some well fields are also utilized in obtaining water for municipal supplies.

Several courses of action are available to the UMA communities in meeting and satisfying their future water supply requirements:

- Developing additional reservoir capacity on an individual basis by each water supply agency. The city of Williamsport is at present developing another reservoir on Hagerman's Run with a total storage capacity of some 530 mg. This reservoir will provide 1.9 mgd additional water to the Williamsport Municipal Water Authority.

- Exploiting further ground water development by each of the communities within the UMA.

- Combining the major existing water systems under one municipal water supply agency, which would be responsible for developing additional resources and administering a regional system.

## CONCLUSIONS

Although a deficit of 1.0 mgd for the entire UMA has been projected to occur by 1980, it is an unlikely occurrence because of the plans by the city of Williamsport to construct another reservoir on Hagerman's Run, which would provide an additional 1.9 mgd.

Regionalization through planning and physical interconnection of systems would enhance the water supply situation through more effective and efficient operations; however, it is unlikely that this course of action will be followed in the near future. Because of the availability of ground water and the number of reservoir sites scattered throughout the area that are potentially amenable for water supply development, the existing systems probably will find it more advantageous for their present and projected needs to develop additional resources on an independent basis.

Nevertheless, the physiography and location of the Williamsport area indicate that an overall system for administering and providing water, by integrating the existing resources and developing new ones from upland reservoirs, ground water aquifers, or locating water from the West Branch Susquehanna River, would be desirable for the UMA.

# CHAPTER 18. ALTOONA

The Altoona Urban Metropolitan Area is located in Blair County, between the Allegheny and Piedmont Plateaus in south-central Pennsylvania. Urban development at present is centered primarily in the city of Altoona, which accounts for more than one-half of the total population of the county.

The climate of the area is generally classified as continental, with considerable variance of temperatures during the warmest and coldest months. The mean temperature at Altoona is about 50°F, with extremes ranging from -22°F to 99°F. The average precipitation is about 40 inches, with an average runoff of 20 inches.

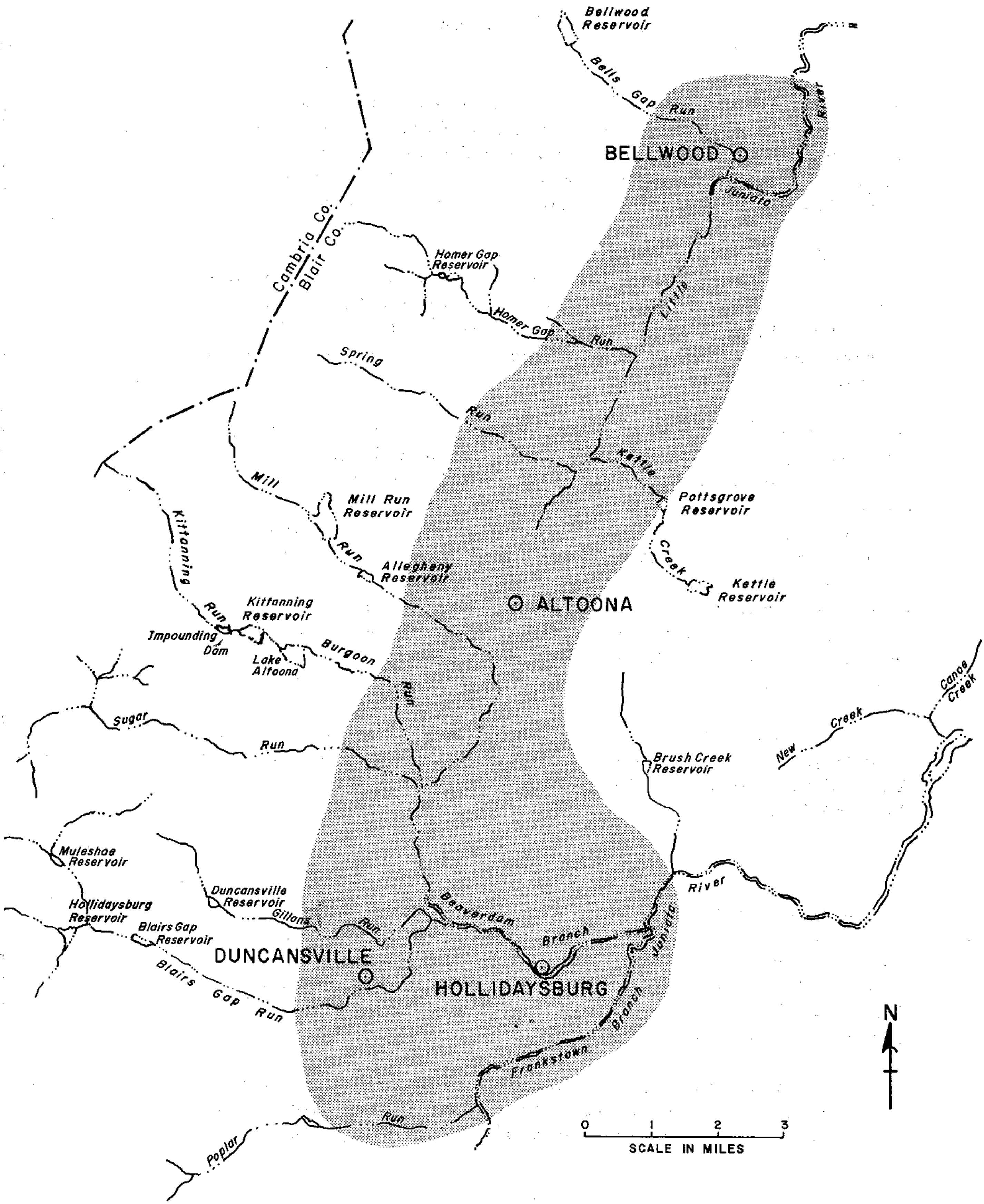
The mountainous topography of the county is broken by three valley areas, Morrison's Cove, Canoe Valley, and Logan Valley. Most of the urban development will continue in the natural corridor of Logan Valley, which lies in a northeast-southwest direction. The valley is bordered on the west by an escarpment of the Allegheny Front, and on the east by mountain ridges and steep, narrow valleys. Elevations within Logan Valley range from 900 to 1,200 feet above sea level. The escarpment of the Allegheny Front rises in three well defined steps, reaching an altitude of about 2,400 feet; the mountain ridges to the east are about 2,000 feet in height.

The UMA expected to evolve by the year 2020 covers an area of approximately 60 square miles; it is shown on Figure 55. A list of the components that will be totally or partially within the UMA includes:

<u>Blair County</u>

Allegheny township (part)
Altoona city
Antis township (part)
Bellwood borough
Blair township
Duncansville borough
Frankstown township (part)
Freedom township
Hollidaysburg borough
Logan township (part)
Newry borough

Because of the lack of employment opportunities and the out migration of the young people in the Altoona area, economic and industrial development has been declining since about




**ALTOONA UMA**
**FIGURE 55**



Anderson-Nichols & Co., Inc.

1920. However, the situation has improved during the last few years; at present, Altoona is the center of industry since of over 90 percent of the area in Blair County is farm, forest, or game land. Primary industries include food, apparel and textiles, leather and leather goods, stone, clay and glass products, fabricated metals, and transportation equipment.

Although no interstate highways pass through the UMA, the area is linked with two major east-west highways, U.S. Interstate Routes 80 to the north and 76 to the south, by U.S. Routes 220 and 22, respectively. The main line of the Penn Central Railroad passes through the area in an east-west direction. Air service is available at the Altoona-Blair County Airport, located a short distance southeast of the UMA.

## POPULATION

The principal centers of population include the city of Altoona, Logan township, and the boroughs of Duncansville and Hollidaysburg. According to the 1970 census, these four municipalities had a combined population totalling more than 75 percent of the entire UMA population. Altoona and Hollidaysburg have both declined in population during the past decade, because of the desire of people to move from the older, more urbanized areas to the suburbs. Each of the other areas within the UMA increased in population during the same time period.

Projections indicate that the UMA population will increase by almost 50 percent by the year 2020. Population and density figures for the UMA are shown in Table 67.

TABLE 67

POPULATION DATA

ALTOONA UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 107.6 | 106.5 | 117.0 | 139.0 | 155.5 |
| Population per square mile | 1,795 | 1,775 | 1,950 | 2,315 | 2,590 |

TABLE 68

WATER USAGE

ALTOONA UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 10.5 | 13.3 | 18.2 | 24.0 |
| Publicly-supplied industrial | 1.5 | 2.3 | 4.3 | 8.1 |
| TOTAL M & I | 12.0 | 15.6 | 22.5 | 32.1 |
| Publicly-supplied industrial | 1.5 | 2.3 | 4.3 | 8.1 |
| Self-supplied industrial | 15.0 | 15.0 | 15.0 | 15.0 |
| TOTAL INDUSTRIAL | 16.5 | 17.3 | 19.3 | 23.1 |
| Water Use (gcd) (Based on M & I) | 112.0 | 133.0 | 162.0 | 206.0 |

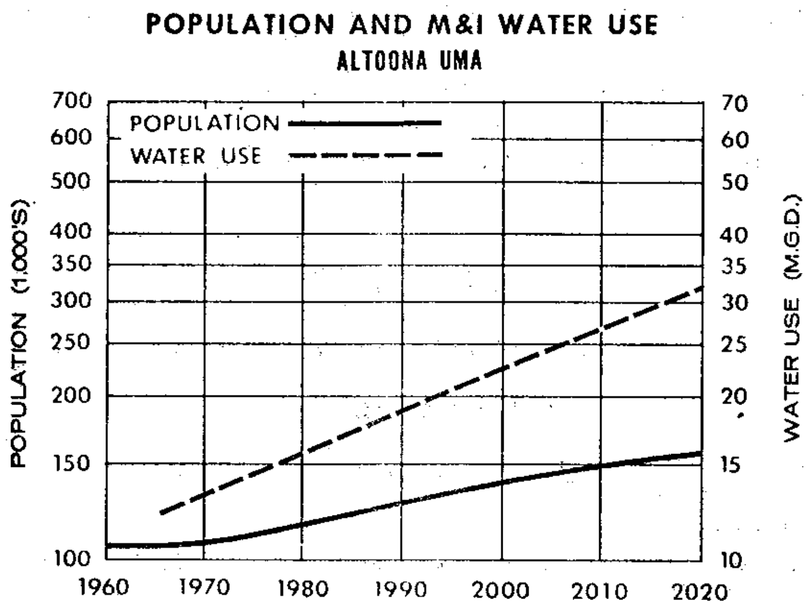



FIGURE 56

## WATER USAGE

Available data indicate that about 107,600 people were served by large and small water systems throughout the UMA during the mid 1960's. The average publicly supplied municipal and industrial demand was at that time about 12 mgd.

The water requirements of the UMA will increase with the growth in population and with new industries. By the year 2020, the UMA will require about 32 mgd to satisfy its M & I requirements, an increase of almost 200 percent.

The projections for water usage within the Altoona UMA are shown on Table 68, while Figure 56 depicts graphically the projected UMA population and water demands.

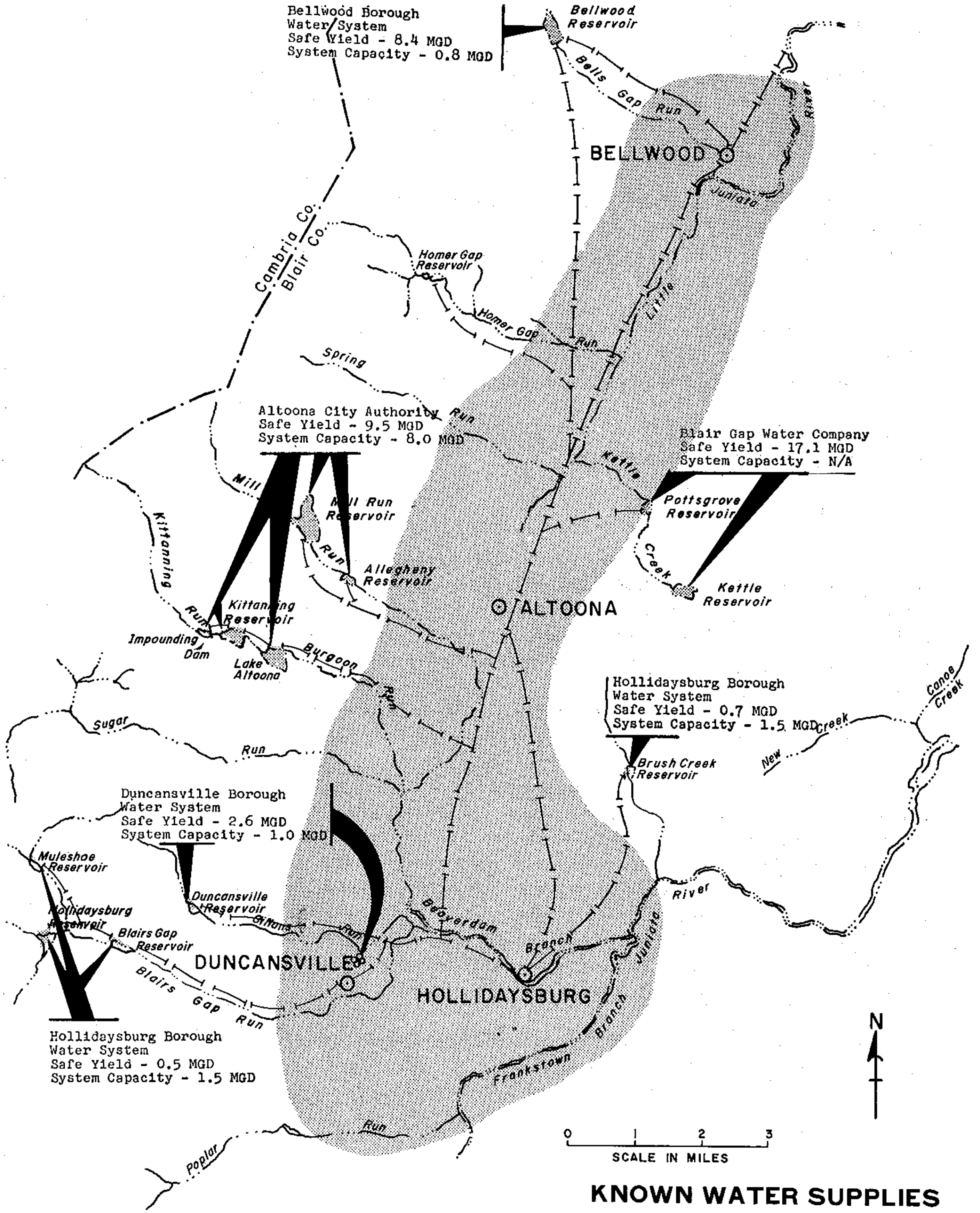
## KNOWN WATER SUPPLIES

### Summary

Five utilities, four public and one private, currently provide water within the UMA boundaries. The largest of the public systems is the Altoona Water Authority, which serves a population exceeding 90,000, both within the city limits and in a large portion of the developed areas outside and contiguous to the city. The remaining three public systems supply water to the boroughs of Bellwood, Duncansville, and Hollidaysburg, and collectively serve over 16,000 people.

The Blair Gap Water Company, (BGWC), a private utility, was formed originally to serve the railroads: It met the water-supply requirements of the steam locomotives which crossed the Allegheny Plateau through the eastern gap, near Altoona; and it provided fire protection for the railroad repair shops, located in and around Altoona. The company currently supplies water on a wholesale and retail basis to about 600 customers within Logan Valley, from Hollidaysburg to Tyrone. (Tyrone is outside of the UMA.)

Figure 57 depicts the known water supplies, and Table 69 contains data essential to each of them.




**KNOWN WATER SUPPLIES ALTOONA UMA**

**FIGURE 57**

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TABLE 69

KNOWN WATER SUPPLIES

ALTOONA UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd)[1] | Treat. Capacity (mgd)[2] | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Altoona City Authority | 90,000 | 7.6 | Surface Reservoirs | Homer Gap | 0.9 | | 8.0 | 8.0 |
| | | | | Mill Run | 1.6 | | | |
| | | | | Allegheny | | | | |
| | | | | Lake Altoona | | | | |
| | | | | Impounding Dam Kittanning Point | 5.0 | | | |
| | | | | Dottsgrove[3] Kettle[3] | 6.2 | | | |
| | | | Ground Water Wells - 3 | | 2.0 | | | |
| Bellwood Borough Water System | 3,000 | 0.5 | Surface Reservoirs | Bells Gap Run Bells Gap[3] | 8.4 | | 0.8 | 0.8 |
| Duncansville Borough Water System | 2,100 | 0.3 | Surface Reservoirs | Maple Hollow Run | 0.7 | | 1.0 | 1.0 |
| | | | Ground Water Wells - 2 | | 1.9 | | | |
| Hollidaysburg | 13,200 | 0.6 | Surface Reservoirs | Muleshoe[3] | | | 1.5 | 1.5 |
| | | | | Hollidaysburg | 5.5 | | | |
| | | | | Blair Gap[3] | | | | |
| | | | | Brush Creek | 0.7 | | | |
| | | | | Kladder Station | 0.5 | | | |
| Blair Gap Water | 960 | 3.0 | Surface Reservoirs | Tipton | 5.4 | | N/A | N/A |

[1]Safe yield obtained from "Historical Background and Physiography", Reports 1 & 2, Blair County Planning Commission.
[2]All systems provide for disinfection.
[3]Denotes other Blair Gap Water Reservoirs.

## Future Adequacy

As shown in the preceding table, the combined safe yield of the existing reservoirs in the Altoona area amounts to about 60 mgd. This is more than enough water to meet the projected requirement of 32 mgd, shown in Table 70, for the entire UMA through the year 2020. The amount is not readily available throughout the area, however, because of inadequate transmission and treatment facilities. Greater treatment capability is needed to cope with occasional acid-mine drainage contamination and high turbidity problems, especially during periods of high runoff. Moreover, only small portions of some watersheds not affected by acid-mine drainage are suitable as catchment areas for reservoirs.

TABLE 70

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

ALTOONA UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 12.0 | 15.6 | 22.5 | 32.1 |
| Present Capability (mgd) | 12.0* | 12.0 | 12.0 | 12.0 |
| Deficit (mgd) | -- | 3.6 | 10.5 | 20.1 |

*Although the existing reservoirs, as indicated on Table 69, have an aggregate safe yield of about 60 mgd, the present capability to supply water is 12 mgd (the amount served in the mid 1960's) due to transmission and treatment limitations.

Some of the UMA municipalities have drawn plans to improve the four public water supply systems. Their published report lists future courses of action.

- The city of Altoona plans to build a water treatment plant and develop ground water sources to augment its present capacity.

- Bellwood borough intends to increase its transmission capacity from Bells Gap Reservoir to the borough.

- Duncansville borough has recently completed a successful deep well, capable of 1,000 gpm, to augment the water supply obtained from Duncansville Reservoir. Additional ground water investigations will be carried out in the near future, along with renovation of existing transmission lines.

- The Hollidaysburg system intends to make further improvements to its existing transmission mains, to increase the present capacity by 33 percent. Also, improvements to the existing watershed are in the planning stage. Hollidaysburg has indicated that it might investigate the possibilities of ground water development, especially since Duncansville has had success in its development of ground water aquifers.

## DESIRABILITY FOR REGIONALIZATION

A regional or "areawide" approach for providing sufficient water to meet the expected demands throughout the UMA has been recognized by the Blair County Regional Planning Commission as the best way to avoid future water supply problems. A study has recently been completed for the Planning Commission for inclusion in its "Areawide Comprehensive Plan" for Blair County.

## DEVELOPMENT ALTERNATIVES

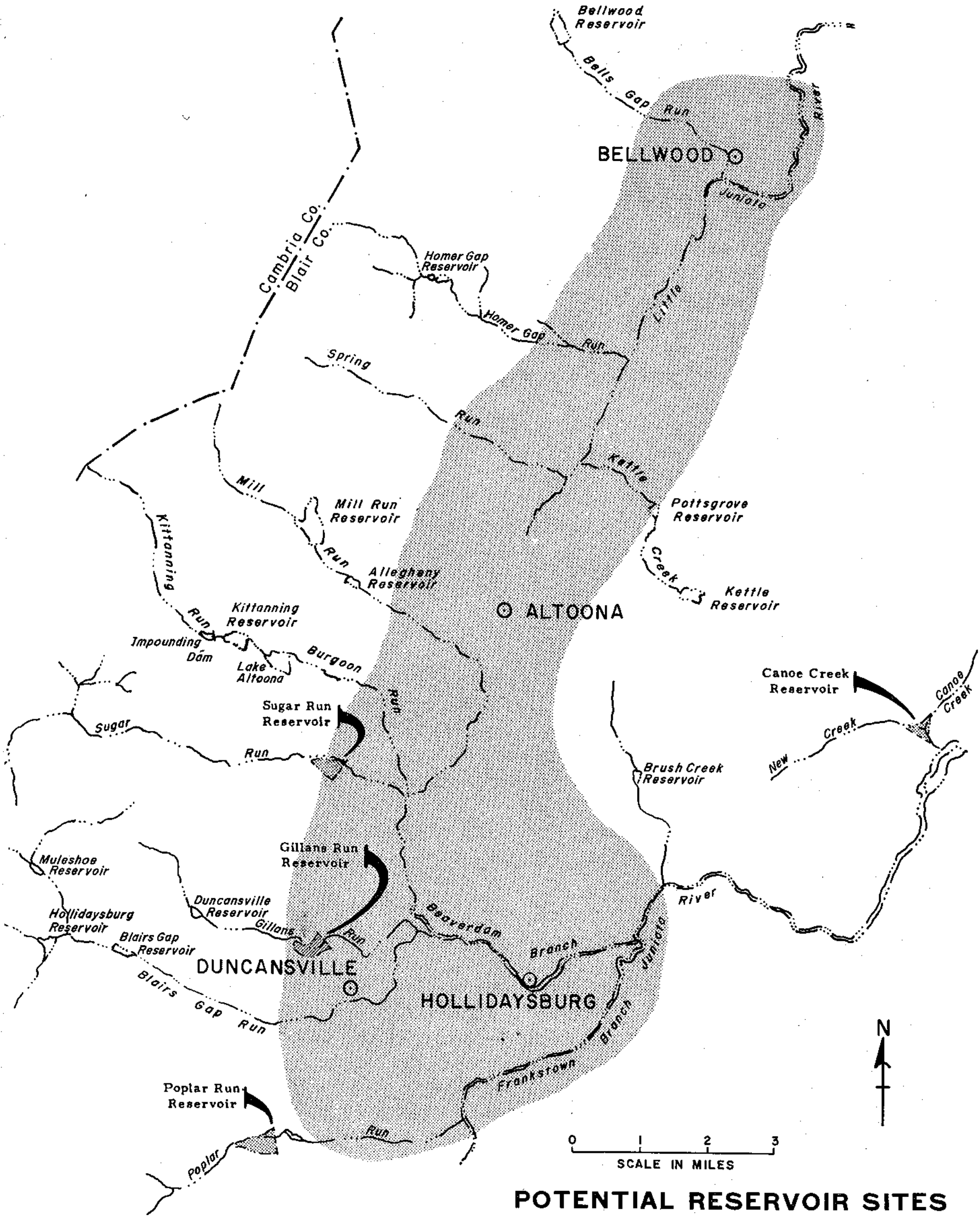
Various alternatives for meeting the projected water requirements of the Altoona UMA have been proposed, in the Blair County Study and elsewhere.

### Surface Water Resources Development

In its 1966 report, "Upstream Reservoir Sites," to be included in the Susquehanna River Basin Study, the U.S. Department of Agriculture identified several reservoir sites possible for development within Blair County. Four of the sites are potentially amenable to water supply development to benefit the Altoona UMA. The combined safe yield of the reservoirs would exceed 36.4 mgd. Table 71 indicates the safe yield which could be developed at each of them, and Figure 58 shows their locations.

### Ground Water Development

Although few municipalities currently utilize ground water for supply, the U.S. Geological Survey has indicated in its report, An Appraisal of the Ground Water Resources of the Juniata River Basin, March 1966, that Blair County has a significant sub-surface water resource potential. Ground water developments, particularly in Altoona and in the boroughs of




POTENTIAL RESERVOIR SITES
ALTOONA UMA

FIGURE 58



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TABLE 71

POTENTIAL RESERVOIR SITES

ALTOONA UMA

| Name of Stream | Drainage Area Square Miles | Estimated Safe Yield, mgd |
|---|---|---|
| Sugar Run | 8.6 | 6.7 |
| Gillans Run | 2.7 | 2.1 |
| Poplar Run | 11.9 | 9.2 |
| Canoe Creek | 23.7 | 18.4 |

Duncansville and Hollidaysburg, have barely tapped the potential supply. Duncansville has been successful in its development of a deep well, capable of producing 1,000 gpm, or about 1.5 mgd. Hollidaysburg and Altoona are both currently investigating the feasibility of well-field development to augment their supplies.

Integration of Existing Water Systems

The five major water systems have supplies from existing reservoirs that are more than adequate to meet the projected demand of 32 mgd in the year 2020. The limiting factors preventing maximum utilization of this water at present, however, include inadequate transmission and pumping facilities, and inadequate treatment capacity during times of high runoff.

In order to meet the demands expected as soon as 1980, the five major systems should fully integrate their existing water supply sources and transmission mains. By increasing transmission capacity through the renovation and interconnection of existing facilities, or construction of any needed additional facilities, an adequate supply of water would be readily available throughout the UMA.

Interconnection has, to some extent, already been employed by the privately owned BGWC, whose transmission mains run from Newry borough in the south to Tyrone in the north. Because of its several reservoirs, the BGWC has been able to effect interconnections with each of the four municipal systems; the four, however, are not interconnected.

## CONCLUSIONS

A deficit of about 20 mgd is predicted for 2020 for the Altoona UMA, even though the developed source capacity is 60 mgd. Obviously, transmission and treatment capacity must be increased. The one private system is already interconnected with the four public systems, despite the elongated geographic configuration of the UMA.

A logical approach in meeting expected water supply deficits throughout the Altoona UMA seems to be mass interconnection of the five major systems, preferably under a single management, or through a central planning organization capable of:

- Renovating reservoirs for full utilization of developed water resources;

- Interconnecting both existing and future transmission and pumping facilities, to convey sufficient water to the various demand centers of the UMA; and

- Developing additional potential surface and ground water sources of water, to augment present source capability where such additions would be economically more desirable.

Such an approach should provide enough water to meet the overall requirements for the Altoona UMA, thus precluding any projected deficits.

# CHAPTER 19. ALLENTOWN-BETHLEHEM-EASTON

The Allentown-Bethlehem-Easton Urban Metropolitan Area lies almost entirely in the Lehigh River Basin of Pennsylvania, extending into New Jersey to include the town of Phillipsburg and its environs. Located about 70 miles west of New York City and 50 miles northwest of Philadelphia, the UMA is about 35 miles long, from the southern boundary of Lehigh County to the confluence of the Lehigh and Delaware Rivers at Easton, and encompasses a total area of approximately 430 square miles. The municipalities comprising the UMA follow; the area is delineated on Figure 59.

PENNSYLVANIA

Lehigh County:

- Alburtis borough
- Allentown city
- Bethlehem city (part)
- Catasauqua borough
- Coopersburg borough
- Coplay borough
- Emmaus borough
- Fountain Hill borough
- Hanover township
- Lower Macungie township
- Macungie borough
- North Whitehall township
- Salisbury township
- Slatington borough
- South Whitehall township
- Upper Macungie township
- Upper Milford township
- Upper Saucon township
- Washington township
- Whitehall township

Northampton County:

- Allen township
- Bath borough
- Bethlehem city (part)
- Bethlehem township
- East Allen township
- Easton city
- Forks township
- Freemansburg borough
- Glendon borough
- Hanover township
- Hellertown borough
- Lehigh township
- Lower Nazareth township
- Lower Sauson township
- Nazareth borough
- Northampton borough
- North Catasauqua borough
- Palmer township
- Stockertown borough
- Tatamy borough
- Upper Nazareth township
- Walnutport borough
- West Easton borough
- Wilson borough

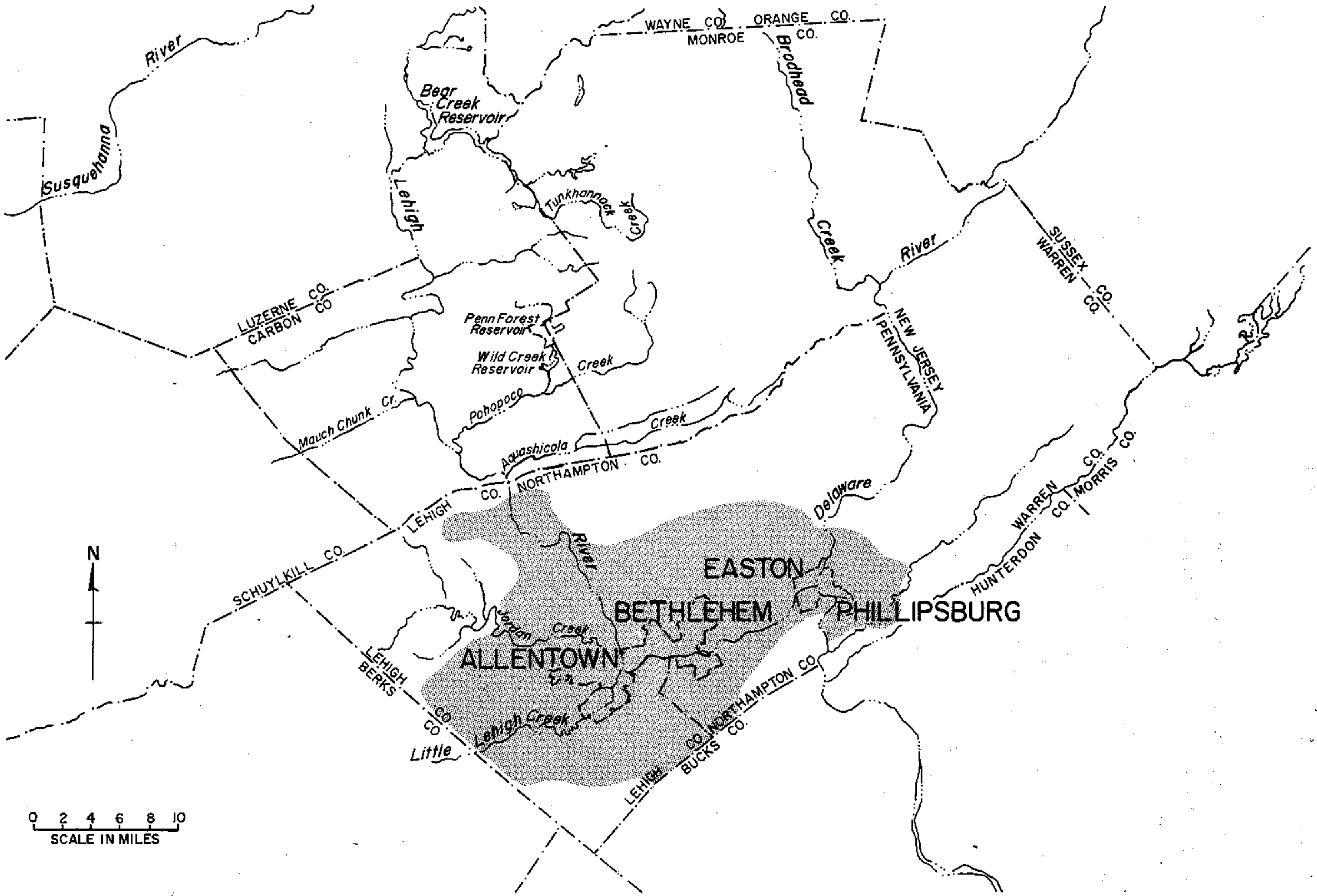


FIGURE 59

ALLENTOWN-BETHLEHEM-EASTON UMA

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NEW JERSEY

Warren County:

Alpha borough
Greenwich township
Lopatcong township
Phillipsburg town
Pohatcong township

The UMA falls within two physiographic regions, the Great Valley and New England provinces, both of which are part of the Appalachian Highlands. Forming the northern border of the Great Valley province are the Blue-Kittatinny Mountains, while broad, hilly-to-rolling ridges make up the highland area of the New England province. The physiographic regions are effectively separated by the Lehigh River, as it flows northeast to its confluence with the Delaware River at Easton; but the Lehigh also serves as the boundary between Lehigh and Northampton Counties, from Catasaqua southeast as far as Allentown.

Elevations within the UMA range from 200 ft. above sea level, near the Lehigh and Delaware Rivers, to 1000 ft. in the highlands of the New England province.

The climate is continental, with mild winters and moderate to hot summers. The average temperature is 50°F, with January and July averages of 32°F and 75°F, respectively. Precipitation ranges from 42 to 45 inches within the UMA, while the total accumulated snowfall is generally between 30 and 40 inches. A west to southwest overland dry air flow is responsible for occasional summer droughts.

The Allentown-Bethlehem-Easton UMA is an important stepping-stone along major transportation corridors to the north and west from Philadelphia and New York, respectively. The Northeast Extension of the Pennsylvania Turnpike and Pennsylvania Route 309 provide access south to Philadelphia, and north to the cities of Hazelton, Wilkes-Barre, and Scranton, Pennsylvania. In addition, Pennsylvania Route 115 travels northward to Stroudsburg and joins Interstate Route 80, a major east-west connection. Interstate Route 78 and Pennsylvania Route 22 connect the major cities of the UMA to the east and west.

Rail transportation to all major eastern cities is extensive; the UMA is served by the Central Railroad of New Jersey, Erie-Lackawanna Railroad, Lehigh Valley Railroad, Penn

Central Railroad, Reading Railroad, and Lehigh and New England Railroad. Air service is provided chiefly by the Allentown-Bethlehem-Easton Airport at Lehigh Valley, Pennsylvania, which offers service on three major trunk lines and two regional carriers. Numerous small airfields throughout the UMA can accommodate light aircraft; and the major airports of Newark, New York, and Philadelphia are within reasonable driving distance.

The UMA became an industrial region early in its development, specializing in iron and steel, and textile products. The close proximity to Pennsylvania's anthracite coal region made mining a major industry until only recently, when it declined. At present, major industries include textiles and apparel, food, electrical and non-electrical machinery, and fabricated metals. Recreation has become an additional important source of regional employment.

## POPULATION

The present centers of population are the cities of Allentown, Bethlehem, and Easton, Pennsylvania, and Phillipsburg, New Jersey, in which cities over 50 percent of the area's population of 415,000 is concentrated. According to the 1970 census, Allentown gained slightly in population between 1960 and 1970; but Bethlehem and Easton have been declining since the 1950's. The result is a healthy growth rate for the towns and villages surrounding the urban centers. The overall gain in population in the UMA during the 1960's decade was about 37,000, an increase of 9 percent.

Projections for the future indicate a somewhat more even population distribution pattern within the UMA, because the presently rural and suburban areas are expected to grow at a faster rate than the industrial and commercial centers. Population and population density data are presented in Table 72, and the anticipated future population trend is depicted graphically on Figure 60.

## WATER USAGE

Available data indicate that about 416,000 people and several industries received approximately 59.0 mgd from 17 large and small water supply systems during the mid 1960's. At that time, domestic usage was approximately 41 mgd expected to rise to 94 mgd by the year 2020. Industrial water

TABLE 72

POPULATION DATA

ALLENTOWN-BETHLEHEM-EASTON UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 415.0 | 452.0 | 491.0 | 584.4 | 667.8 |
| Population per square mile | 965 | 1,050 | 1,140 | 1,360 | 1,555 |

usage estimated to be about 308 mgd at present, is expected to increase to 531 mgd by 2020. While only about 6 percent of the industrial demand is currently being provided by public systems, the industries will require a greater percentage of water from public supplies in the future. Data pertinent to water usage are presented in Table 73, and graphically on Figure 60.

## KNOWN WATER SUPPLIES

### Summary

Four major and 13 minor public and private water supply systems provided service to the UMA in the mid 1960's. The Allentown Bureau of Water and the Bethlehem Municipal Water Works together supplied more than 50 percent of the population served, with the average daily demand from all systems within the UMA approaching 60 mgd at that time. The eastern part of the UMA is served primarily by the remaining two major systems. The Easton Water Bureau (and

TABLE 73

WATER USAGE

ALLENTOWN-BETHLEHEM-EASTON UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 41.0 | 52.0 | 71.0 | 94.0 |
| Publicly-supplied industrial | 18.0 | 36.0 | 65.0 | 106.0 |
| TOTAL M & I | 59.0 | 88.0 | 136.0 | 200.0 |
| Publicly-supplied industrial | 18.0 | 36.0 | 65.0 | 106.0 |
| Self-supplied industrial | 290.0 | 324.0 | 371.0 | 425.0 |
| TOTAL INDUSTRIAL | 308.0 | 360.0 | 436.0 | 531.0 |
| Water Use (gcd) (Based on M & I) | 142 | 179 | 233 | 300 |

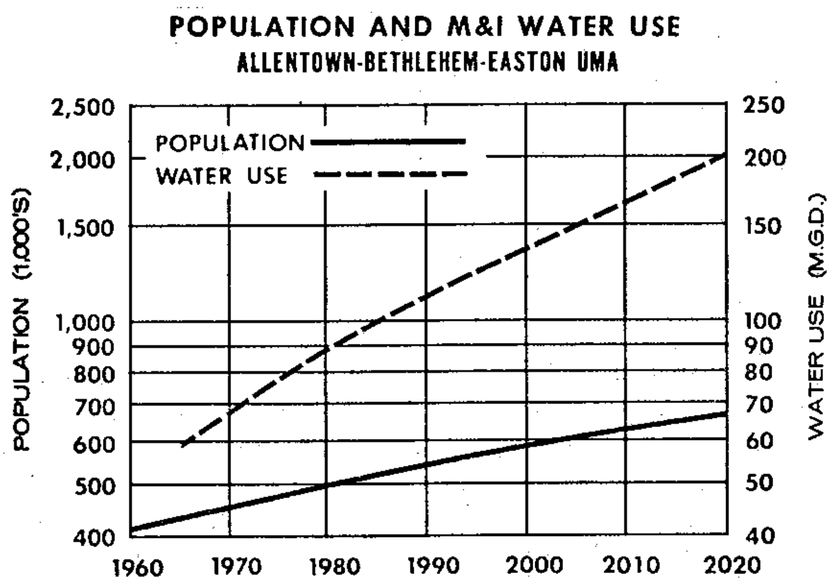



FIGURE 60

Easton Suburban Water Authority) with an 8 mgd treatment plant, has a 10 mgd allocation of water from the Delaware River Basin Commission. The Peoples' Water Company serves the Phillipsburg, New Jersey area. Its source is ground water obtained from infiltration galleries along the Delaware River. The large municipal systems obtain their supply primarily from surface sources, while small public and private systems rely almost exclusively on wells and springs for water.

Table 73 lists pertinent data for the four major systems, and summarizes the 13 minor systems within the UMA, while Figure 61 locates some of the facilities of the major systems.

TABLE 74

KNOWN WATER SUPPLIES

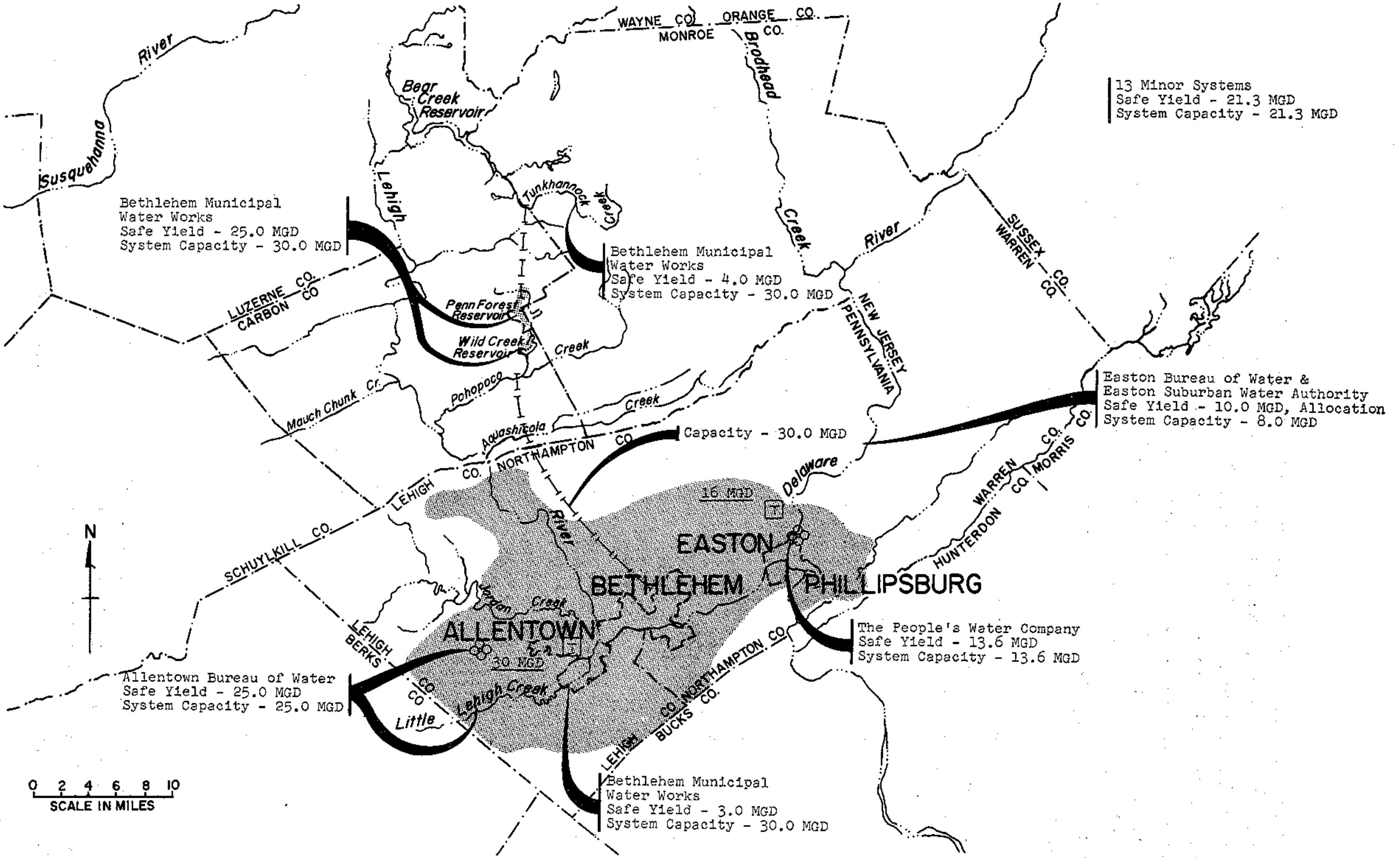
ALLENTOWN-BETHLEHEM-EASTON UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Allentown Bureau of Water | 112,000 | 20.4 | Surface | Little Lehigh Cr. | 16.0 | 30.0 | | 25.0 |
| | | | Ground | Crystal Spring | 9.0 | | | |
| | | | Ground | Schantz Spring | | | | |
| Bethlehem Municipal Water Works | 110,000 | 21.0 | Surface | Wild Creek | 25.0 | | 30 | 30.0 |
| | | | Surface | Penn. Forest Res | | | | |
| | | | Surface | Tunkhannock R. Diversion | 4.0 | | | |
| | | | Ground Water Wells | | 3.0 | | | |
| Easton Bureau of Water & Easton Suburban Water Authority | 60,000 | 5.6 | Surface | Delaware River | 10.0* | 8 | 53.8 | 8.0 |
| The People's Water Company | 20,000 | 4.5 | Ground Water Wells | Infiltration Gallery from Delaware R. | 13.6 | | | 13.6 |
| 13 Minor Systems | 114,000 | 5.8 | Surface & Ground Water | | 21.3 | | | 21.3 |

*Allocation

## Future Adequacy

The aggregate rated capacity of all the water supply systems serving the Allentown-Bethlehem-Easton UMA is about 98 mgd. When compared with the projected demands in Table 75, a deficit in water supply capability does not appear until




KNOWN WATER SUPPLIES
ALLENTOWN-BETHLEHEM-EASTON UMA

FIGURE 61

sometime between 1980 and 2000. It is important to note, however, that with 17 utilities involved, many not interconnected, the composite deficit is somewhat misleading: the true deficit could be larger and may occur sooner, particularly in the western part of the UMA or, in those rural areas presently supplied by ground water systems, unless remedial action is planned and implemented. On the other hand, some areas probably will have adequate supplies for the next 50 years.

The major water supply problem for the UMA for the future exists in the development of sources. From Table 75, it is evident that sources yielding about 100 mgd must be developed prior to 2020. As they are developed, transmission and treatment facilities must be constructed to accommodate the purification and transportation of water to communities within the UMA.

TABLE 75

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

ALLENTOWN-BETHLEHEM-EASTON UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 59.0 | 88.0 | 136.0 | 200.0 |
| Present Capability (mgd) | 97.9 | 97.9 | 97.9 | 97.9 |
| Deficit (mgd) | -- | -- | 38.1 | 102.1 |

## DESIRABILITY FOR REGIONALIZATION

Each of the four major systems is a regional supplier, because each provides water to a large city and its environs. Similarly, nearly all of the minor systems serve more than one municipality.

The Allentown Bureau of Water supplies water to the city of Allentown and the townships of Salisbury, South Whitehall, and Whitehall, having a combined population of more than 112,000 - about 25 percent of the population within the UMA.

The Bethlehem Municipal Water Works serves the next largest population, over 110,000, throughout the city of Bethlehem and all or parts of the townships and boroughs of Hanover, Allen, Bethlehem, Freemansburg, Fountain Hill, Lower Saucon, Upper Saucon, and Lower Nazareth.

The Easton Bureau of Water and Suburban Water Authority serves more than 60,000 people within the city of Easton, and all or portions of the surrounding Glendon Borough, Forks Township, W. Easton Borough, Wilson Borough, and Palmer Township.

The People's Water Company in Warren County, New Jersey, provides water service to a population of about 20,000 in the Phillipsburg area.

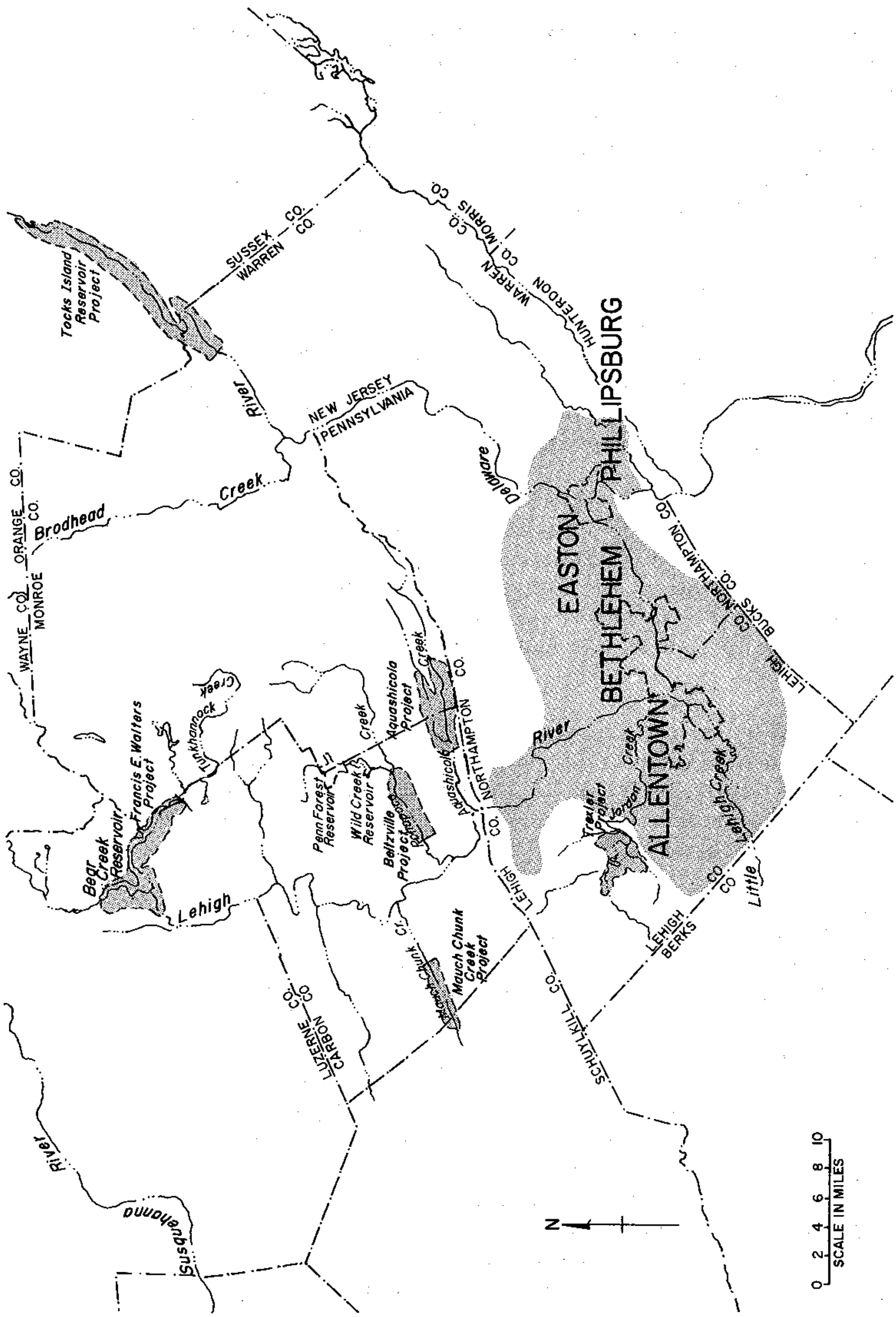
Each of the four major utilities, however, operates as a separate entity, with its own source of water supply and its own management system. No interconnections between any of these systems are known to exist.

As the population of the UMA expands to areas that are presently rural in nature, it will become increasingly desirable to utilize the talents and facilities of the four major systems to effect regional water supply service throughout these areas. The predominate sources of water for the rural areas are presently wells; therefore, the decision will have to be made by the small water companies whether to interconnect with the large regional systems or to seek further individual ground water sources. Economics must be the determining factor.

With an investigation of the possibilities of interconnecting the pumping, transmission, and treatment facilities of the four major utilities, an even greater degree of regionalization could be implemented. This would, in turn, result in the most efficient utilization of resources throughout the UMA. The Joint Planning Commission for Lehigh and Northampton Counties has investigated methods of instituting a totally regional water supply authority for the UMA, but their recommendations have not been made available for this study.

## DEVELOPMENT ALTERNATIVES

A review of several potential sources of supply for future development indicates that direct withdrawal from the Lehigh and Delaware Rivers should supply the major portion of future water needs for the Allentown-Bethlehem-Easton UMA, provided that the water quality of the rivers is improved, and




**POTENTIAL SOURCES OF SUPPLY**
**ALLENTOWN-BETHLEHEM-EASTON UMA**
**FIGURE 62**



Anderson-Nichols & Co., Inc.

that the degree of treatment required can be achieved. Although opportunities for the development of reservoirs within the UMA exist, sites would be scarce and relatively small, considering projected water demands. Similarly, ground water development has not been extensive, probably because of the lack of abundant resources; its development will most likely be confined to the more rural areas of the UMA.

Lehigh River

The construction of Beltzville Reservoir, located on Pohopoco Creek, a tributary of the Lehigh River, was recently completed by the U.S. Army, Corps of Engineers. The project, part of the long-range water resources development program in the Delaware River Basin, is expected to be in full operation in the near future.

The multipurpose reservoir will reportedly maintain low-flow objectives of 35 cfs on Pohopoco Creek at Parryville, 400 cfs on the Lehigh River at Bethlehem, and 2,700 cfs on the Delaware River at Trenton. The reservoir will contribute to flood and water-quality control, as well as water-oriented recreation.

The reservoir has a total storage capacity of over 22 billion gallons, of which about 9 billion gallons will be available for water supply. With a drainage area above the dam of about 75 square miles, the project will provide a safe yield available for water supply of about 52 mgd.

Municipalities in the Allentown-Bethlehem vicinity could pump and receive water from the Beltzville Reservoir via transmission mains, but it would prove more economical to withdraw directly from the Lehigh River near Bethlehem.

The purchase and allocation of 52 mgd from the Beltzville Reservoir would seem to eliminate any further need for source development for the western portion of the Allentown-Bethlehem-Easton UMA. In the event that 52 mgd could not be obtained from this project, however, or that this amount does not prove adequate, several other projects on tributaries of the Lehigh River have been proposed by the Corps of Engineers, the Delaware River Basin Commission, and State and local agencies. Projects included in this category are discussed in detail in Chapter 21, Philadelphia-Trenton-Wilmington under Potential Sources of Supply. The projects, which are shown on Figure 62, include: Tocks Island Reservoir; Trexler Reservoir; Aquashicola Reservoir; Mauch Chunk Creek Reservoir; the Francis E. Walters modification; and the Susquehanna-Lehigh Diversion. Recent influxes of water-using industries, as reported by the Lehigh County Authority, indicate that Trexler Reservoir should be built by 1990.

Any combination of these projects would contribute to the satisfaction of water requirements of both the Allentown-Bethlehem-Easton and Philadelphia-Trenton-Wilmington UMA's: water withdrawn from the Lehigh River in the Allentown-Bethlehem area would be returned almost entirely to the river as sewage effluent, and hence to the Philadelphia-Trenton-Wilmington area via the Delaware River.

### Delaware River

The Delaware River has proven in the past to be a reliable source of water for municipalities in the Easton-Phillipsburg area. With a drainage area of over 6,000 square miles above its confluence with the Lehigh River, the Delaware provides an average flow of over 7,000 mgd. Even under the most severe drought conditions, the flow was over 700 mgd for the record one-day low flow.

At present, the system capacities are limited by an allocation to Easton of 10 mgd, and by the size or number of infiltration galleries of the People's Water Company in the Phillipsburg area. As demands dictate, increased direct intake facilities on the Delaware could be constructed with very little effect on the river's flow, since only a small portion of the withdrawal would be consumed, and most would be returned to the river as sewage effluent.

## CONCLUSIONS

The presently developed sources of supply and facilities should be adequate to meet public demands until the year 1990 in the Allentown-Bethlehem-Easton UMA with the exception of western Lehigh County. Additional source development will be needed there.

Interconnections of many systems, as well as the establishment of a single regional administration, appears to be desirable, thus effecting a greater degree of effectiveness and efficiency.

Future source development for the urban centers probably will largely depend on withdrawal from the Lehigh and Delaware Rivers, providing water quality can be improved. Some ground water development is expected for rural communities. Timely construction of necessary facilities to develop the withdrawals should prevent the anticipated deficits from materializing.

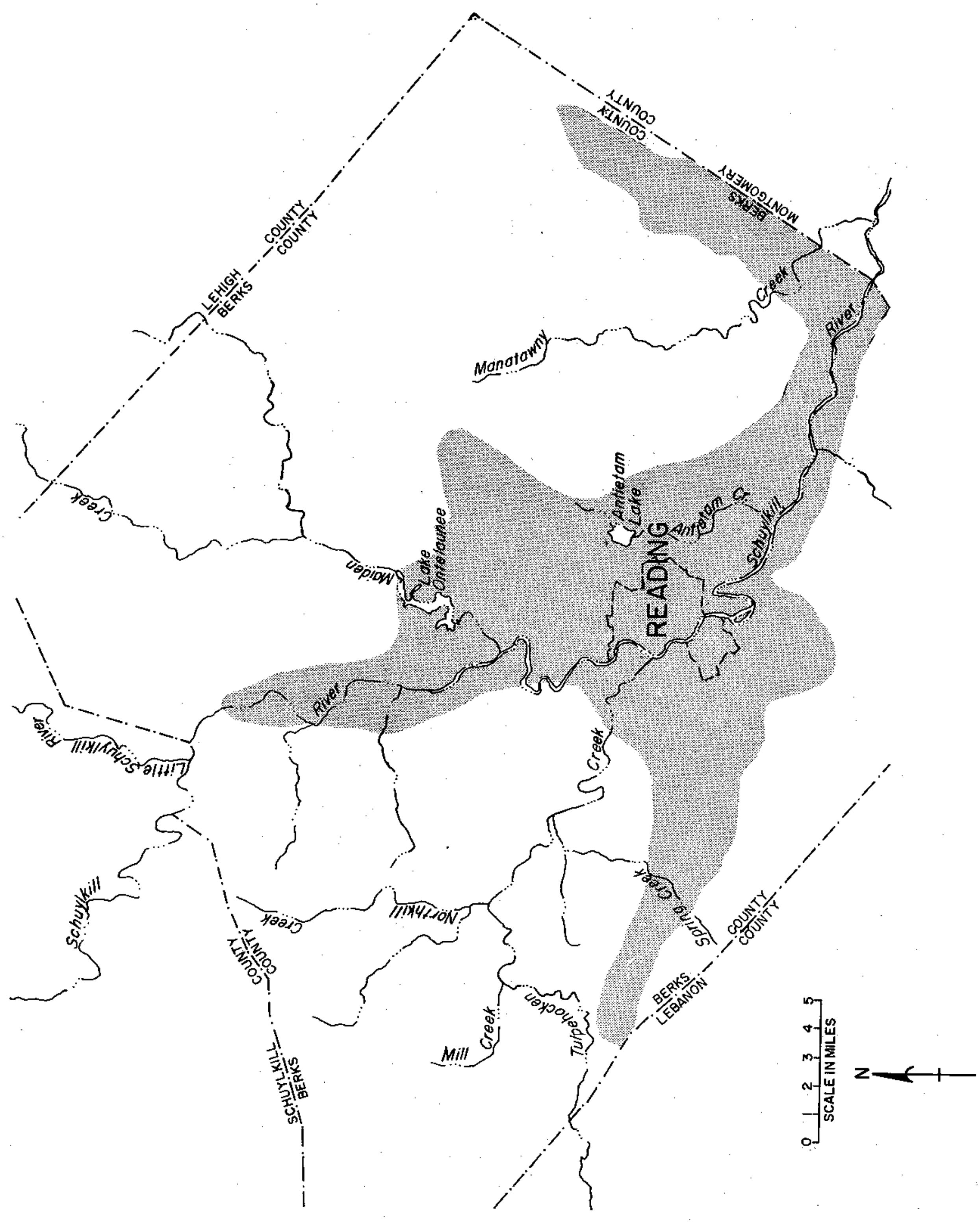
# CHAPTER 20. READING

The Reading Urban Metropolitan Area is situated in Berks County, on the banks of the Schuylkill River in southeastern Pennsylvania. Its location affords easy access to the major metropolitan areas on the east coast: New York City is 125 miles to the northeast; Philadelphia is 45 miles southeast; and Baltimore is 100 miles south.

The UMA, with Reading as its geographic center, encompasses nearly 275 square miles. The main body extends outward approximately 6 miles from Reading, and urban corridors stretch along the Schuylkill River north toward Hamburg and southeast toward Pottstown. A third corridor follows Pennsylvania Route 422 and the area as far as Womelsdorf. The UMA is shown on Figure 63, and its municipalities follow:

<u>Berks County</u>

Alsace township
Amity township
Bally borough
Bechtelsville borough
Bern township
Birdsboro borough
Boyertown borough
Colebrookdale township
Cumru township
Douglass township
Exeter township
Fleetwood borough
Hamburg borough
Heidelberg township
Kenhorst borough
Laureldale borough
Leesport borough
Lower Alsace township
Lower Heidelberg township
Maidencreek township
Mohnton borough
Mount Penn borough
Muhlenberg township
Ontelaunee township
Perry township
Reading city
Robesonia borough
Ruscombmanor township
St. Lawrence borough
Shillington borough
Shoemakersville borough
Sinking Spring borough
South Heidelberg township
Spring township
Temple borough
Washington township
Wernersville borough
West Lawn borough
West Reading borough
Womelsdorf borough
Wyomissing Hills borough
Wyomissing borough






READING UMA
FIGURE 63

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The topography of much of the UMA is indicative of the Great Valley physiographic province, which extends through the central portions of Berks County. Here are found gently rolling hills and valleys, with mean altitudes about 500 feet above sea level. In the southern parts of the UMA are the heavily wooded, rugged hills, steep valleys and irregular ridges characteristic of the New England physiographic province, and elevations extend to 1,000 feet. The Schuylkill River enters the county through the Blue Mountains at Port Clinton, flows southward to Reading, and finally assumes a southeasterly direction to its exit at Pottstown. The elevations of the entire county range from 150 feet above sea level near the Schuykill River at Pottstown, to 1,600 feet in the Blue Mountains.

The Reading UMA has a modified humid continental climate. The average temperature is 54°F, while summer and winter temperatures vary from the mid-seventies to slightly below freezing. The average precipitation at Reading is approximately 41 inches, but the county average is 48-49 inches; its runoff is approximately 20 inches.

Berks County and the Reading UMA have adequate transportation facilities to link the area with other nearby metropolitan centers. Pottstown and Harrisburg are reached via Pennsylvania Route 442, while Pennsylvania Route 222 provides access to Lancaster and Allentown. Interstate Route 176 from Reading meets the Pennsylvania Turnpike at Morgantown, to the south.

The Reading Railroad System and Penn Central Transportation Company provide rail transportation, and air service is provided by four commercial and nine private landing fields.

The largest segment of the labor force in Berks County is in the employ of the manufacturing industries, the majority of which are located within the UMA. Production is in apparel and textiles, food processing, fabricated metals, transportation and equipment, and non-electrical machinery, retail and wholesale trade and services also employ a substantial number of people, and have helped in the economic development of the Reading UMA.

## POPULATION

Population is rising slowly in the UMA; an increase of only about 5 percent was observed between 1960 and 1970. Although the city of Reading, economic and social core of the region, has lost population steadily over the last 30 years, nearly all of the surrounding 41 towns have grown, at least since 1960.

The UMA appears to have a solid economic base with no clearly discernable defects or faults. Hence, it is expected that demographic and industrial growth will progress smoothly over the study time frame of 50 years. Projections indicate that the area will increase in population from about 239,300 to more than 379,000 by the year 2020, an increase of nearly 60 percent. Population and density figures for the UMA are shown in Table 76.

TABLE 76

POPULATION DATA

READING UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 228.1 | 239.3 | 252.0 | 308.0 | 379.0 |
| Population per square mile | 830 | 870 | 915 | 1120 | 1380 |

## WATER USAGE

Available data indicate that about 216,300 people and several industries received approximately 84 mgd from the large and small public water supply systems during the mid 1960's. Domestic usage in the mid 1960's approximated 16.6 mgd and is expected to be 42.7 mgd by the year 2020. Industrial usage, an estimated 43.5 mgd in the mid 1960's is expected to increase to 73.6 mgd. Less than one-third of the industrial demand is being supplied publicly, at present, but it is believed that the future industrial requirements will be met by public systems. Data pertinent to water usage are presented in Table 77, and graphically on Figure 64.

TABLE 77

WATER USAGE

READING UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 16.6 | 21.5 | 30.3 | 42.7 |
| Publicly-supplied industrial | 13.5 | 17.0 | 25.5 | 43.6 |
| TOTAL M & I | 30.1 | 38.5 | 55.8 | 86.3 |
| Publicly-supplied industrial | 13.5 | 17.0 | 25.5 | 43.6 |
| Self-supplied industrial | 30.0 | 30.0 | 30.0 | 30.0 |
| TOTAL INDUSTRIAL | 43.5 | 47.0 | 55.5 | 73.6 |
| Water Use (gcd) (Based on M & I) | 139.5 | 153.0 | 181.0 | 228.0 |

POPULATION AND M&I WATER USE

READING UMA

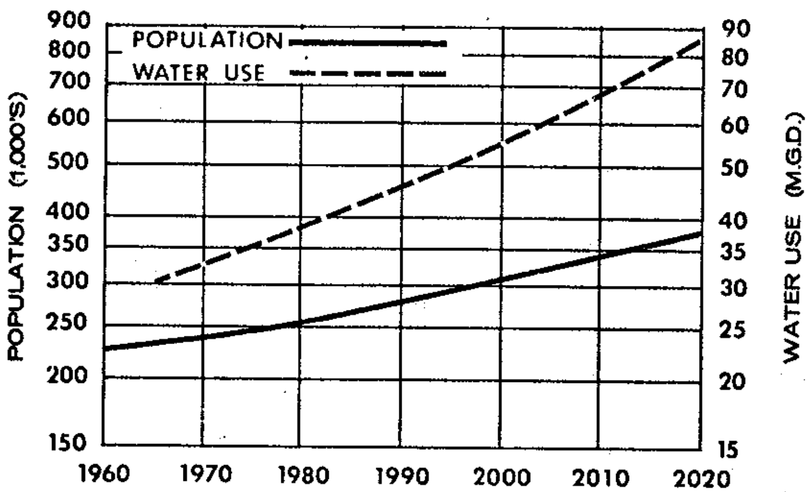



FIGURE 64

## KNOWN WATER SUPPLIES

### Summary

Over 20 public and private water supply companies provided service of more than 30 mgd to 206,000 residents of the Reading UMA in the mid 1960's. Reading Municipal Water Department, the largest utility, alone supplied 123,000, or about 60 percent of the total service population. Within the UMA, surface water is the common source for the urban areas, while ground water is predominant as a supply source in rural areas and for small requirements. Table 78 lists pertinent data for the Reading Municipal Water Department, the Citizens Utilities Water Company, the Mount Penn Water Authority, and the minor supply systems, and Figure 65 locates the sources. Recently, the Western Berks County Water Authority was formed; note, however, that it is not shown in Table 78, since it has not yet supplied water in the UMA.

TABLE 78

KNOWN WATER SUPPLIES

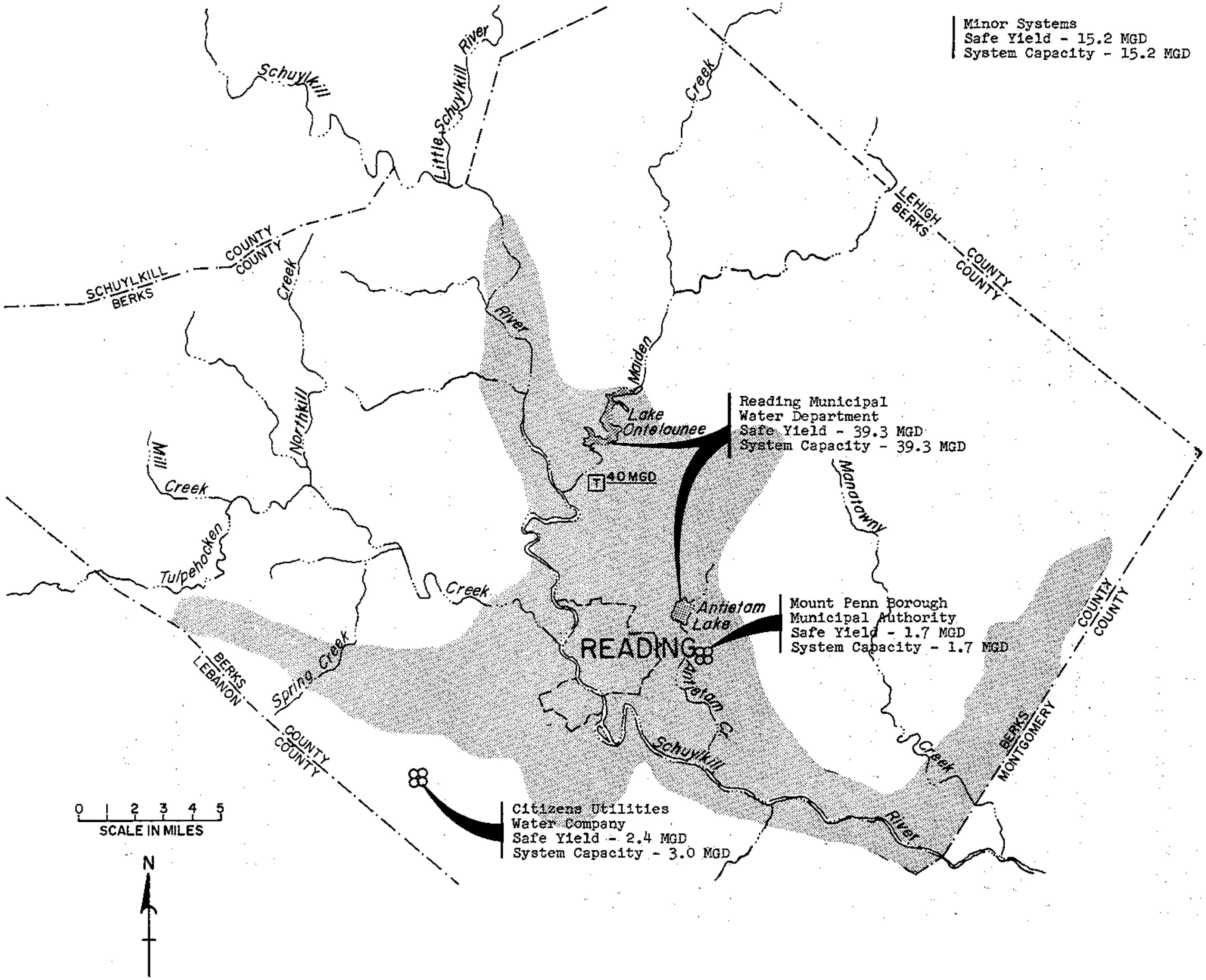
READING UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Reading Municipal Water Department | 123,000 | 20.6 | Reservoir | Lake Ontelaunee | 37.0 | 40.0 | | 35.0 1/ |
| | | | Reservoir | Antietam Lake | 2.3 | | | |
| | | | Ground Water | | | | | |
| Citizens Utilities Water Company | 14,800 | 1.2 | Wells Ground Water | | 3.0 | | | 3.0 |
| Mount Penn Water Authority | 12,000 | 0.6 | Wells | | 1.6 | | | 1.7 |
| | | | Surface | | 0.1 | | | |
| Minor Systems | 56,700 | 7.7 | Surface | | 8.2 | | | 15.2 |
| | | | Ground Water | | | | | |
| | | | Wells | | 5.7 | | | |
| | | | Springs | | 1.3 | | | |

1/ Capacity limited to 35.0 mgd by allocation.

### Future Adequacy

The present aggregate rated capacity of water supply systems serving the Reading UMA is about 54.9 mgd, which will become 64.9 mgd when the 10 mgd capacity of a new treatment plant, to be placed on line shortly by the Western Berks County Water Authority, is added. The new plant will treat water from the Blue Marsh Reservoir, located on Tulpehocken

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**KNOWN WATER SUPPLIES**
**READING UMA**
**FIGURE 65**

Creek, in 1976; in the interim, it will treat water withdrawn directly from the creek.

When this figure is compared with projected demands, as in Table 79, a deficit in water supply capability will not occur until sometime after the year 2000. It is important to note, however, that with more than 20 utilities involved, many not interconnected, the composite deficit is somewhat misleading. The true deficit could be larger and may occur sooner, particularly in those rural areas presently served by ground water systems, unless remedial action is planned and implemented. On the other hand, areas such as the one served by the Reading Municipal Water Department may experience no water shortage within the next 50 years.

Nevertheless, the major future water supply problem for the Reading UMA exists in the development of sources. Additional sources should be developed by 2000, and sources yielding more than 30 mgd must be developed before 2020. Transmission and treatment facilities must also be constructed with the newly developed sources, to accomodate the purification and transportation of water.

TABLE 79

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

READING UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 30.1 | 38.5 | 55.8 | 86.3 |
| Present Capability (mgd) | 54.9 | 64.9 | 64.9 | 64.9 |
| Deficit (mgd) | -- | -- | -- | 21.4 |

## DESIRABILITY FOR REGIONALIZATION

In a broad sense, regionalization already exists within the Reading UMA, since the Reading Municipal Water Department provides service to 60 percent of the total UMA population, both within the city and in several contiguous boroughs and towns.

As the urban growth extends to rural areas, it will become increasingly desirable to utilize the talents and facilities from the Reading system. Most rural sources of water are, at present, wells; but the decision to be made by the small water companies -- whether to interconnect with the large regional system, or to seek further independent sources -- will depend largely on economics.

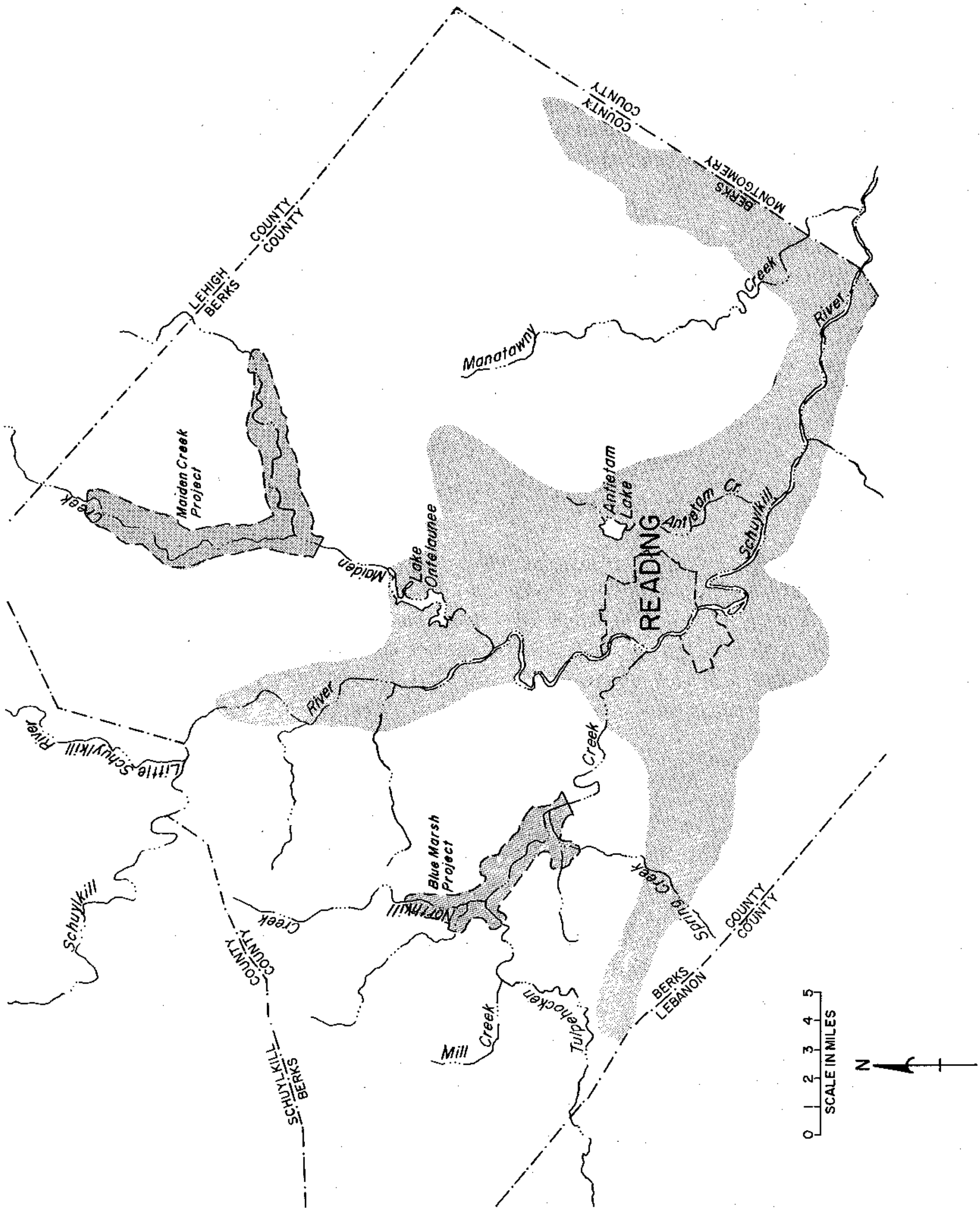
## DEVELOPMENT ALTERNATIVES

Several alternative courses of water supply development are available to the Reading UMA: (1) Blue Marsh Reservoir; (2) Maiden Creek Reservoir; (3) small local reservoirs, and (4) ground water. Brief descriptions of these potential sources and projects follow; Figure 66 shows the Blue Marsh and Maiden Creek Reservoirs.

### Blue Marsh Project

Blue Marsh Reservoir, to be located on Tulpehocken Creek, a tributary of the Schuylkill River, was designed by the U.S. Army, Corps of Engineers, during 1964 and 1965. The project is a part of the long range water resources development program in the Delaware River Basin. Design of Blue Marsh has been completed, and it is scheduled for early construction and operation after 1975. (See also Chapter 21.)

The multi-purpose reservoir reportedly will contribute to the satisfaction of water needs in both the Reading and Philadelphia UMA's, reduce flood stages on the Schuylkill River from Reading to Philadelphia, and accomodate over a hundred thousand visitors annually for recreational purposes. The reservoir will have a total storage capacity of 16.3 billion gallons, of which about 4.8 billion gallons will be available for water supply. With a drainage area above the dam of 175 square miles, the project will provide a safe




POTENTIAL SOURCES OF SUPPLY
READING UMA
FIGURE 66



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yield available for water supply of about 45 mgd; 31.0 mgd has already been allocated for water supply by the Delaware River Basin Commission (DRBC).

The newly formed Western Berks Water Authority will utilize this reservoir as its primary source of supply for several communities west of the Schuylkill River. The Authority, with planned allocation rights to 7 mgd, will reportedly withdraw water directly from the reservoir. The availability of the entire 31.0 mgd allocation from this project would preclude the need to develop additional water resources in the UMA throughout the time frame of this study. However, it is unlikely that the DRBC would allocate all of the additional 24 mgd needed to effect this; but perhaps a total of up to 15 mgd may be authorized for Reading.

Construction costs of about $25 million are anticipated for the reservoir development.

Maiden Creek Project

Maiden Creek Reservoir, to be located on Maiden Creek, another tributary of the Schuylkill River, has been proposed by the U.S. Army Corps of Engineers as part of the water resources development program for the Delaware River Basin. The project is only in the planning stages; it will not be constructed until needs dictate, and until considered economically desirable.

The multi-purpose reservoir would reduce flood stages in the Schuylkill River, provide recreation, and contribute to the satisfaction of water needs in the Reading and/or Philadelphia areas.

Constructed to a spillway elevation of 307 feet above sea level, the reservoir would have a storage capacity of 37 billion gallons, of which 24 billion gallons would be available for water supply. With a drainage area above the dam of 161 square miles, the project would provide a safe yield available for water supply of over 87 mgd.

Construction costs on the order of $28 million could be expected for this reservoir.

### Local Reservoirs

The Berks County Planning Commission had its consultant investigate about 60 surface water sites that might serve as small water supply reservoirs. The results of the preliminary investigations revealed that only five small sites were hydrologically sound to warrant study.

### Ground Water

Ground water is the predominant source of supply in the rural areas of the Reading UMA. About 12 mgd are presently obtained from wells and springs in the area and distributed to municipalities by several small supply systems.

It is generally believed that large amounts of ground water may be available from aquifers scattered throughout Berks County; however, since no large wells have as yet been located, ground water does not appear to be a major source for the UMA.

## CONCLUSIONS

The future water supply situation in the Reading UMA appears favorable, because local planners have kept water resource developments well ahead of future needs. The area is amenable to a regional water supply concept, through both planning and physical interconnections.

Construction of Blue Marsh Reservoir on Tulpehocken Creek in the future and the resulting allocation of 31 mgd to the Reading area would preclude the necessity for future water source development there. However, if this amount cannot be obtained, or if actual demands prove to be far higher than those anticipated, a reservoir on Maiden Creek would be a desirable supplement.

# CHAPTER 21. PHILADELPHIA-TRENTON-WILMINGTON

The Philadelphia-Trenton-Wilmington UMA is situated in the lower portion of the Delaware River Basin, midway between New York City and Baltimore. Its eastern fringe is 30 to 50 miles inland from the Atlantic Coast, and the entire region extends approximately 85 miles, from the urbanized area of Trenton, New Jersey, to the region south of Wilmington, Delaware, as shown on Figure 67. The area covers portions of four states: Pennsylvania, New Jersey, Delaware, and Maryland, and surrounds the Delaware River.

The total land area of the UMA is approximately 2,640 square miles, or about 53 percent of the total area of the Philadelphia, Trenton, and Wilmington Standard Metropolitan Statistical Areas which comprised the initial study area. The municipalities which are included in the UMA follow:

## PENNSYLVANIA

Bucks County:

Bensalem
Bristol borough
Bristol
Buckingham (part)
Chalfont borough
Doylestown borough
Doylestown
Dublin borough
East Rockhill (part)
Falls
Hilltown
Hullmerville borough
Ivyland borough
Langhorne borough
Langhorne Manor borough
Lower Makefield
Lower Southampton
Middletown
Milford
Morrisville borough
New Britain borough
New Britain
Newtown borough
Newtown
Northampton
Penndel borough
Perkasie borough
Plumstead (part)
Quakertown borough
Richland
Richlandtown borough
Sellersville borough
Silverdale borough
Telford borough
Trumbauersville borough
Tullytown borough
Upper Makefield (part)
Upper Southampton
Warminster
Warrington
Warwick
West Rockhill
Yardley borough

Chester County:

Atglen borough
Avondale borough
Birmingham
Caln
Charlestown
Coatesville city
Dowington borough
East Bradford
East Brandywine
East Caln
East Coventry
East Fallowfield
East Goshen
East Marlboro
East Nottingham
East Pikeland
Easttown
East Vincent
East Whiteland
Kennett
Kennett Square borough
London Grove
Lower Oxford
Malvern
Modena
New Garden
New London
North Coventry
Oxford borough
Parkesburg borough

Chester County (continued):

Penn
Pennsbury
Phoenixville borough
Pocopson
Schuylkill
South Coatesville borough
South Coventry
Spring City borough
Sudsbury
Thornbury
Tredyffrin
Upper Uwchlan
Uwchlan
Valley
West Bradford
West Brandywine
West Caln
West Chester borough
West Goshen
West Grove borough
West Sudsbury
Westtown
West Whiteland
Willistown

Delaware County: Entire county.

Montgomery County:

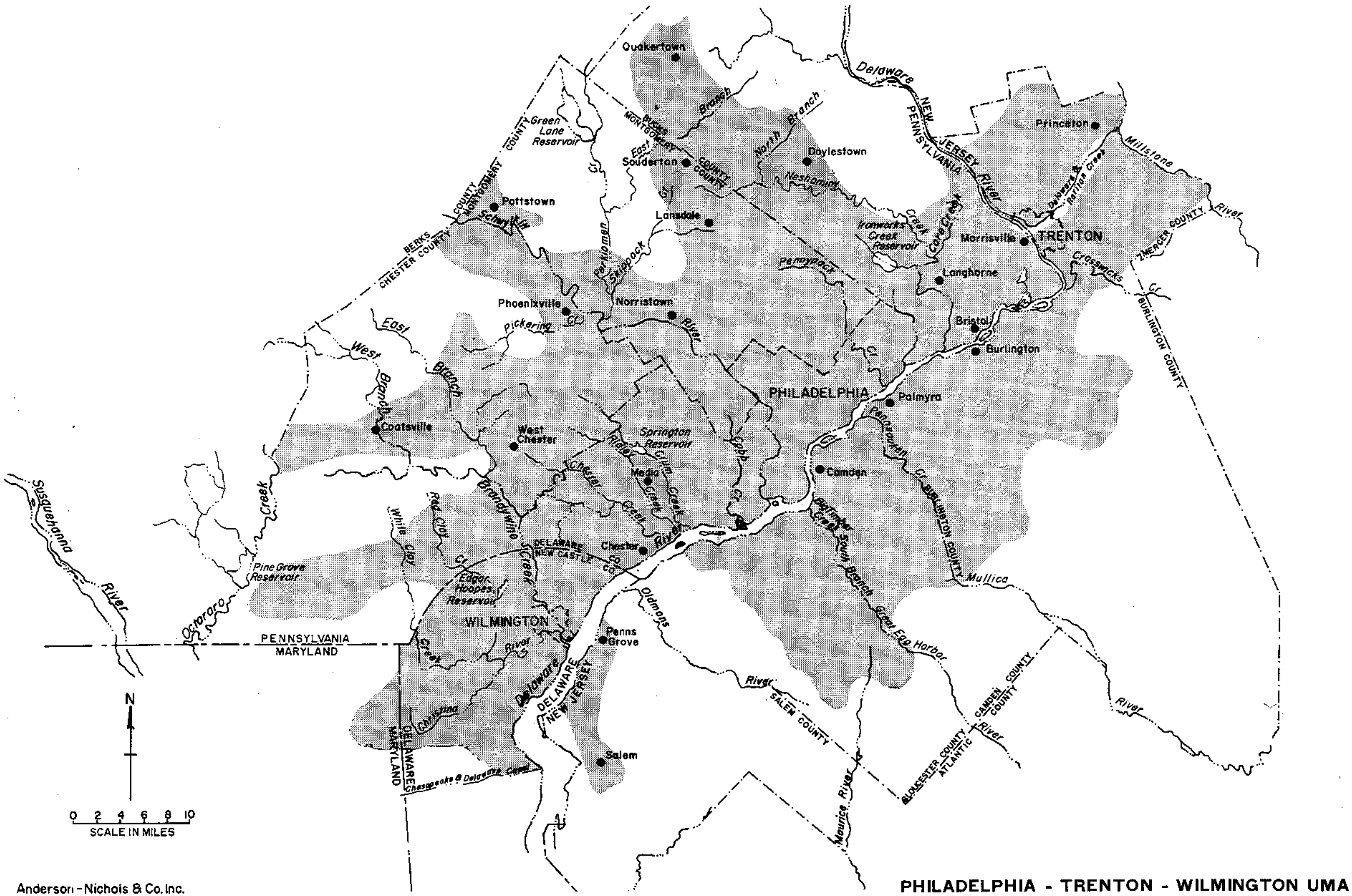
Abington
Ambler borough
Bridgeport borough
Bryn Athyn borough
Cheltenham
Collegeville borough
Conshohocken borough
East Norriton
Franconia
Hatboro borough
Hatfield borough
Hatfield
Horsham
Jenkintown borough
Landsdale borough
Lower Gwynedd
Lower Merion
Lower Moreland
Lower Pottsgrove
Lower Providence
Montgomery
Narberth borough
Norristown borough
North Wales borough
Plymouth
Pottstown borough
Rockledge borough
Royersford borough
Souderton borough
Springfield
Telford borough
Towamencin
Trappe borough
Upper Dublin
Upper Gwynedd
Upper Merion
Upper Moreland
Upper Pottsgrove
Upper Providence
West Conshohocken borough
West Norriton
West Pottsbrove
White marsh
Whitpain

Philadelphia County: Entire county.

## NEW JERSEY

Burlington County:

Beverly city
Bordentown city
Bordentown
Burlington
Burlington city
Cinnaminson
Delanco
Delran
Easthampton
Edgewater Park
Evesham
Fieldsboro borough
Florence
Hainesport
Lumberton
Mansfield
Maple Shade
Medford
Medford Lakes borough
Moorestown
Mount Holly
Mount Laurel
New Hanover
Palmyra
Pemberton borough
Pemberton
Riverside
Riverton borough
Springfield
Westhampton
Willingboro
Wrightstown

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**PHILADELPHIA - TRENTON - WILMINGTON UMA**

**FIGURE 67**

Camden County:

| | | |
|---|---|---|
| Audubon borough | Gibbsboro borough | Merchantville borough |
| Audubon Park borough | Gloucester city | Mount Ephraim borough |
| Barrington borough | Gloucester | Oaklyn borough |
| Bellmawr borough | Haddon | Pennsauken |
| Berlin borough | Haddonfield borough | Pine Hill borough |
| Berlin | Haddon Heights borough | Pine Valley borough |
| Brooklawn borough | Hi-Nella borough | Runnemede borough |
| Camden city | Laurel Springs | Somerdale borough |
| Clementon borough | Lawnside borough | Stratford borough |
| Collingswood borough | Lindenwold borough | Travistock borough |
| Cherry Hill borough | Magnolia borough | Voorhees |
| | | Woodlynne borough |

Mercer County: Entire county.

Salem County:

| | | |
|---|---|---|
| Penns Grove borough | Pennsville | Salem city |
| | | Upper Pennsneck |

DELAWARE

New Castle County (census divisions):

| | | |
|---|---|---|
| Brandywine | Greater Newark | Pike Creek |
| Central Kirkwood | Lower Christiana | Red Lion |
| Central Pencader | New Castle | Upper Christiana |
| | | Wilmington |

MARYLAND

Cecil County:

| | |
|---|---|
| Elkton District No. 3 | Fairhill District No. 4 |

The Philadelphia-Camden area is the main core of the UMA, and second only to New York in population in the greater North Atlantic Region. Population and economic projections for the entire UMA indicate that the area will at least maintain, if not increase, its level of importance in future years.

The topography varies widely throughout the UMA. The dominant physical feature is the Delaware River, which connects the three major cities, and which is an important factor in the historical and economic development of the area. The Schuylkill, the major tributary of the Delaware, enters the UMA in the vicinity of Pottstown, Pennsylvania, and travels southeasterly to its confluence with the Delaware at Philadelphia.

The UMA contains two physiographic divisions, the Atlantic Coastal Plain and the Piedmont Province, divided by the Fall Line, which intersects the three major cities. To the north of the Fall Line is the Piedmont Province, divided into upland and lowland regions. The upland region, located generally south of the Schuylkill River, is marked by irregular ridges and rolling hills. The higher elevations of the UMA are in this region, and reach about 900 feet above sea level, with a gradual decrease in elevation as the Fall Line is approached. The lowland portion of the Piedmont Province lies north of the Schuylkill River, and has broad valleys and generally undulating terrain. Elevations vary from 300 to 600 feet above sea level, gradually decreasing toward the Fall Line.

The Atlantic Coastal Plain is to the south of the Fall Line, and includes portions of the UMA in New Jersey and Delaware along the west bank of the Delaware River. Since parts of this region are at sea level or slightly below, the River is a tidal estuary which extends up to Trenton, New Jersey. The area is generally flat, with occasional hills rarely exceeding elevations greater than 150 feet.

The UMA is in the temperate zone and has a continental climate. Air masses dominate the climate, normally moving from the interior of North America, and modified by the Great Lakes and the Appalachian Mountains. The average temperature varies from 49°F to 55°F, the higher temperatures occurring in the southern portions. Rare extremes reach below zero and above 100°F. Average precipitation is recorded between 25 and 42 inches, the northern portions of the UMA receiving the greater amounts.

The location of the Philadelphia-Trenton-Wilmington area affords an important link in the transportation network connecting the East Coast. All methods of transportation, including highway, rail and air facilities, are available throughout the UMA.

Highways

Numerous interstate highways provide connections to the major cities surrounding the area, and proposed extensions and additions will secure the continued good transportation for the future UMA. Connections extending to New York and Baltimore are provided by the New Jersey Turnpike, U.S. Route 1, and Interstate Routes 95 and 295, the latter two presently under construction. The North-South Freeway and the Atlantic City Expressway provide access to the Atlantic Coast. The scenic Pennsylvania Turnpike, which connects with the New Jersey Turnpike south of Trenton, traverses the region to the north of Philadelphia, and continues on to Harrisburg and the western portions of the state. The Turnpike also joins the Schuylkill Expressway to provide access south to Philadelphia; and its Northeastern Extension links the UMA with the Allentown-Bethlehem area.

### Mass Transit

Subway and rapid transit rail lines currently provide service within the city of Philadelphia, with extensions to Media and Norristown, Pennsylvania. On the New Jersey side, the Lindenwold line connects Haddonfield and Gibbsboro to the main system. Additions are proposed for connections to the northeast toward Burlington and Mt. Holly, and to the southeast to Glassboro.

Passenger and freight rail service to all major cities on the Eastern Seaboard is provided by the Penn Central Transportation Company and Reading Railway System.

### Air Service

The Philadelphia International Airport is the primary passenger and freight terminal for the region, accomodating almost all major national and international airlines. Freight, charter, and some passenger services are supported by the Greater Wilmington Airport, Trenton, New Castel, Delaware, and the Mercer County Airport, Trenton, New Jersey. Numerous smaller air fields are located throughout the UMA.

The UMA contains many diversified industries. The greatest concentration of employment is in electrical machinery, chemicals, apparel and food; but other major industries include printing and publishing, primary metals, machinery and transportation equipment. Within Philadelphia, much of the labor force is engaged in trade, finance, public administration, and professional and business services. Philadelphia's chief manufactured products are textiles, apparel, and primary metals.

Philadelphia is the second largest port in the United States, and situated nearly 100 miles from the Atlantic Ocean. Although the port is used heavily by the Philadelphia Naval Shipyard and associated armed forces facilities, its primary activities are in importing iron ore and crude petroleum, and exporting coal and grain.

Camden, New Jersey, is situated due east of Philadelphia on the opposite shore of the Delaware River, and is especially noted for the processing of food products and the manufacture of electrical equipment. Camden is, essentially, an integral economic subdivision of Philadelphia.

Trenton, located at the head of navigation on the Delaware River, twenty miles upstream from Philadelphia, is the capital of New Jersey. It is a manufacturing center: the city's plants produce ceramics, wire and cable, structural steel, rubber goods, asbestos fabrics, chemicals and allied products, and storage batteries. Despite its political and industrial nucleus, however, the area surrounding Trenton is primarily agricultural. Mercer County, of which Trenton is a part, is important for dairy- and truck-farming.

Wilmington, Delaware is twenty miles downstream from Philadelphia, at the head of Delaware Bay and at the confluence of Brandywine Creek and the Christina River. As the home of three major chemical plants, E. I. duPont de Nemours, Inc., Hercules Powder, and Atlas Powder, Wilmington is called the "chemical capital of the world". It is Delaware's largest city, and a port of entry with deep-water locks.

Additional industries in Wilmington include railroad equipment, auto assembling, iron and steel-works, oil refining, plastics, cork, leather, fiber, rubber hose, cotton dyeing and finishing, and meat packing.

## POPULATION

The total population of the Philadelphia-Trenton-Wilmington area is enormous, since the UMA is the second most populous region of the East Coast. It is estimated that the population will increase from the 1970 figure of 5,384,000, to approximately 8,800,000 by the year 2020.

The City of Philadelphia alone accounted for 36 percent of the total 1970 population; but this is expected to decrease to 21 percent by 2020, since the growth rates of the environs are expected to surpass those of the central city. The populations of the rural counties, accordingly, are expected to increase more than those of the urbanized counties.

The 1970 average density of population was estimated at 2040 persons per square mile, although the actual figure may vary from 10,000 to 500 per square mile, as the outer fringes of the UMA are approached. Table 80 presents the UMA population projections, and Figure 68 depicts them graphically.

TABLE 80

POPULATION DATA

PHILADELPHIA-TRENTON-WILMINGTON UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 4,842 | 5,384 | 5,877 | 7,311 | 8,798 |
| Population per square mile | 1,835 | 2,040 | 2,225 | 2,770 | 3,330 |

## WATER USAGE

Available data indicate that, in the mid-1960's, approximately 150 public and private water utilities in the Philadelphia-Trenton-Wilmington UMA supplied an average of 658 mgd to 4,760,000 people and numerous industries. By the year 2020, however, the total M & I demand is expected to increase to 1,990 mgd, or over three times that of the mid-1960's.

Such a large amount of industry operates within the UMA that it would be unrealistic to expect all of the future industrial requirements to be publicly supplied. Consequently, when water usage was predicted, the General Study Methodology, as described in Volume I, Chapter 4, was modified to allow for the assumption that 85 percent of the total industrial water for the future would be self-supplied, and only 15 percent publicly supplied. The percentage figures are in accordance with values presented in the Delaware River Basin Commission's Seventh Water Resources Program.

Trends in water usage are presented in Table 81, and depicted graphically on Figure 68.

## KNOWN WATER SUPPLIES

### Summary

Of the 150 public and private water utilities in the Philadelphia-Trenton-Wilmington UMA, 17 are major systems which provided about 90 percent of the 658 mgd total to more than 83 percent of the population served. The two largest utilities, the Philadelphia Water Department and the Philadelphia Suburban Water Company, together accounted for service to 62 percent of the population.

TABLE 81

WATER USAGE

PHILADELPHIA-TRENTON-WILMINGTON UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 428 | 580 | 820 | 1,130 |
| Publicly-supplied industrial | 230 | 420 | 600 | 860 |
| TOTAL M & I | 658 | 1,000 | 1,420 | 1,990 |
| Publicly-supplied industrial | 230 | 420 | 600 | 860 |
| Self-supplied industrial | 1,900 | 2,360 | 3,400 | 4,890 |
| TOTAL INDUSTRIAL | 2,130 | 2,780 | 4,000 | 5,750 |
| Water Use (gcd) (Based on M & I) | 138 | 170 | 194 | 226 |

POPULATION AND M&I WATER USE
PHILADELPHIA-TRENTON-WILMINGTON UMA

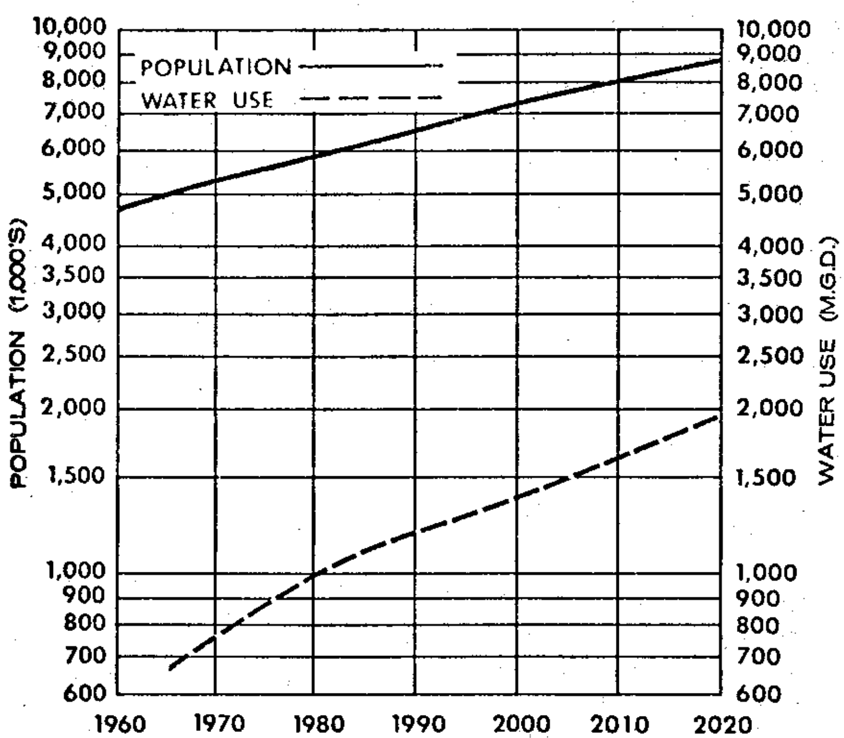



FIGURE 68

All seventeen major utilities have rated capacities of 5 mgd or more, and all are regional in concept, since each serves more than one municipality. However, with the exception of the two largest, the major systems supply separate and localized service areas. There are few emergency connections throughout the UMA, and only in the northern Delaware portion are interconnections extensive.

Table 82 lists pertinent data for the seventeen major utilities, and Figure 69 locates their primary physical facilities.

### Future Adequacy

Because this UMA is so large and complex, a simple comparative analysis of requirements to capacity is not especially meaningful. Therefore, five main service regions were devised, through the consideration of several factors -- existing water supply areas, drainage divides of major sub-basins, areas supplied by a common source, and county boundaries. The five service regions are called the Northwest, West Central, Southwest, Philadelphia City, and Eastern Service Regions, and they delineate the water-deficient areas of the UMA. Figure 70 shows these regions, and Table 83 presents a disaggregation of pertinent population and water use data. Although the service regional boundaries are quite general, they serve to expose localized areas of critical water shortages.

Only the fresh-water demands of self-supplied industrial water together with the M & I water demands have been considered. Stream flow deficiencies resulting from consumptive uses and maintenance of water quality must be replaced from fresh water storage; however consumptive uses of brackish water are generally small. In addition, ground water deficiencies are dependent upon fresh water recharge of the aquifers.

Industry can and does obtain brackish water from the Delaware River estuary for many uses. The cooling water for fossil-fuel power plants, for example, can be brackish; therefore, the power plants should be sited wherever possible to utilize this poorer-quality water. However, with the abundance of fresh water, desalting of brackish water for M & I or other industrial uses does not seem practical.

The amount of raw fresh water needed to meet self-supplied industry in the UMA is significant. Thus, modification of the assumptions in the General Study Methodology of Volume I for application to the Philadelphia-Trenton-Wilmington region permits consideration of the fresh water component of the self-supplied industrial water, together with the total M & I requirements.

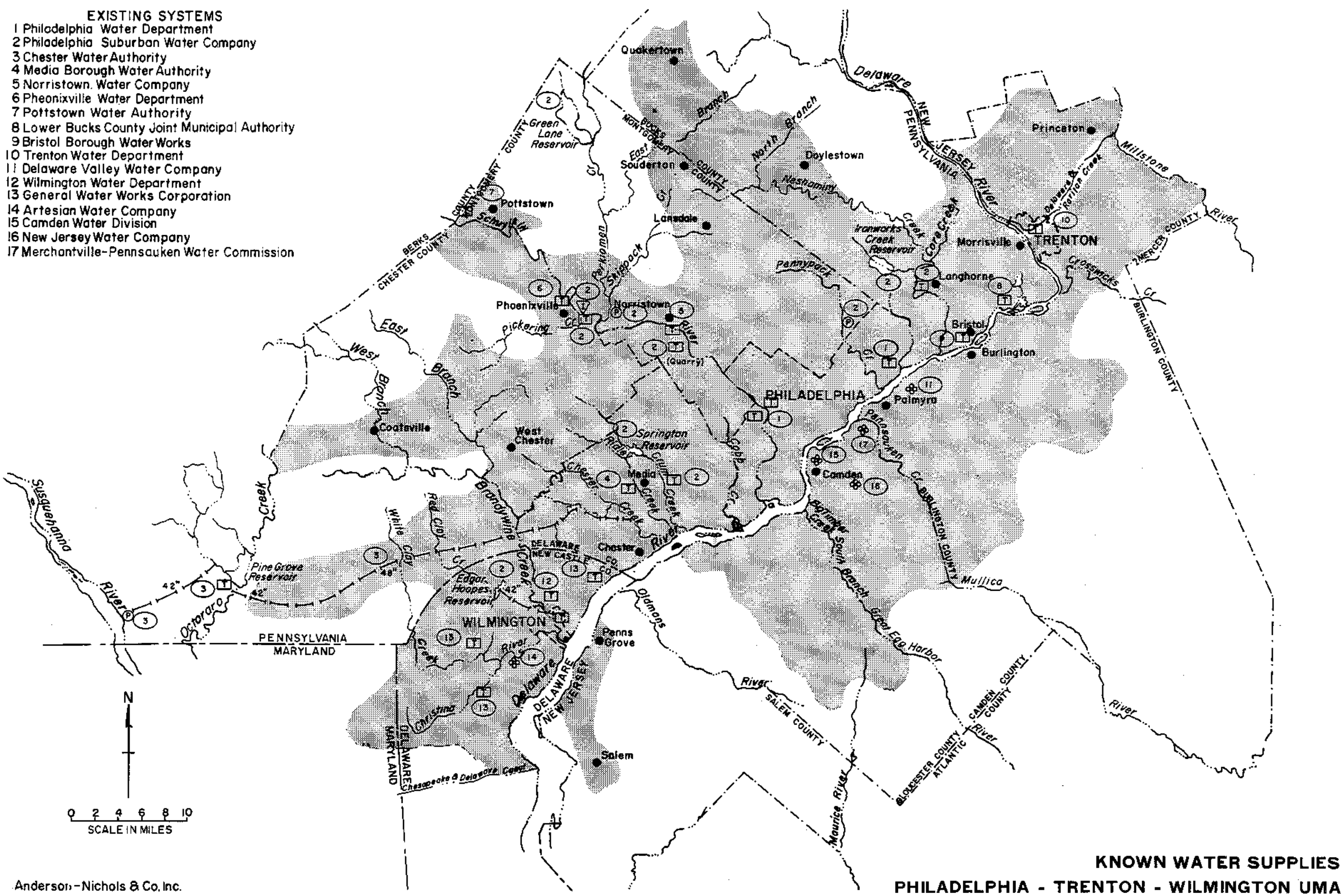
TABLE 82

KNOWN WATER SUPPLIES

PHILADELPHIA-TRENTON-WILMINGTON UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Philadelphia Water Dept. - Public | 2,000,000 | 343.0 | Surface | Delaware R. Schuylkill R. | 681.0 (allocation) | 480 ave. 681 peak | NA | 480.0 |
| Philadelphia Suburban Water Co. - Private | 725,000 | 63.0 | Ground Water Surface Wells | Schuylkill R. Crum Cr. Pickering Cr. Neshaminy Cr. Pennypack Cr. Perkiomen Cr. | 107.0 (total) | 83.0 | NA | 83.0 |
| Chester Water Authority - Private | 110,000 | 24.0 | Surface | Octoraro Cr. Susquehanna R. | 60.0 (allocation) | 50.0 | 60.0 | 50.0 |
| Media Borough Water Authority - Public | 30,000 | 3.0 | Ground Surface | Ridley Cr. Chester Cr. | 6.5 (total) | 7.5 | NA | 6.5 |
| Norristown Water Co. - Private | 65,000 | 7.7 | Surface | Schuylkill R. | 17.5 (allocation) | 16.8 | NA | 16.8 |
| Pnoenixville Water Dept. - Public | 20,000 | 3.4 | Surface | Schuylkill R. | 7.0 (allocation) | 6.0 | NA | 6.0 |
| Pottstown Water Authority - Public | 35,000 | 3.5 | Surface | Schuylkill R. | 8.0 (allocation) | 12.0 | NA | 8.0 |
| Lower Bucks Co. Joint Municipality Authority - Public | 75,000 | 6.4 | Ground Surface | Delaware R. | 22.0 (total) | 16.0 | NA | 16.0 |
| Bristol Borough Water Works - Public | 35,000 | 5.2 | Ground Surface | Delaware R. | | 6.0 | NA | 6.0 |
| Trenton Water Dept. - Public | 210,000 | 32.2 | Surface | Delaware R. | | 50.0 ave. 65.0 peak | NA | 50.0 |
| Delaware Valley Water Co. - Public | 50,000 | 4.7 | Ground | | 16.6 (allocation) | 18.3 | NA | 16.6 |
| Wilmington Water Dept. - Public | 135,000 | 25.8 | Surface | Edgar Hoopes Res. | 63.0 | 52.0 | NA | 52.0 |
| General Waterworks Corp. - Private | 55,400 | 11.6 | Ground Surface | Red Clay Cr. White Clay Cr. Christina R. | 23.0 (total) | 38.3 | NA | 23.0 |
| Artesian Water Co. - Private | 100,000 | 6.9 | Ground | | 16.3 | 13.5* | NA | 16.3 |
| Camden Water Division - Public | 84,800 | 22.5 | Ground | | 37.0 (allocation) | | NA | 37.0 |
| New Jersey Water Co. - Private | 172,000 | 14.1 | Ground | | 32.6 | 28.7* | NA | 32.6 |
| Merchantville-Pennsauken Water Commission - Public | 55,000 | 6.0 | Ground | | 12.5 | 12.5 | NA | 12.5 |
| Minor Systems (133) | | | | | | | | 120.0 |

*Not all of supply requires treatment.

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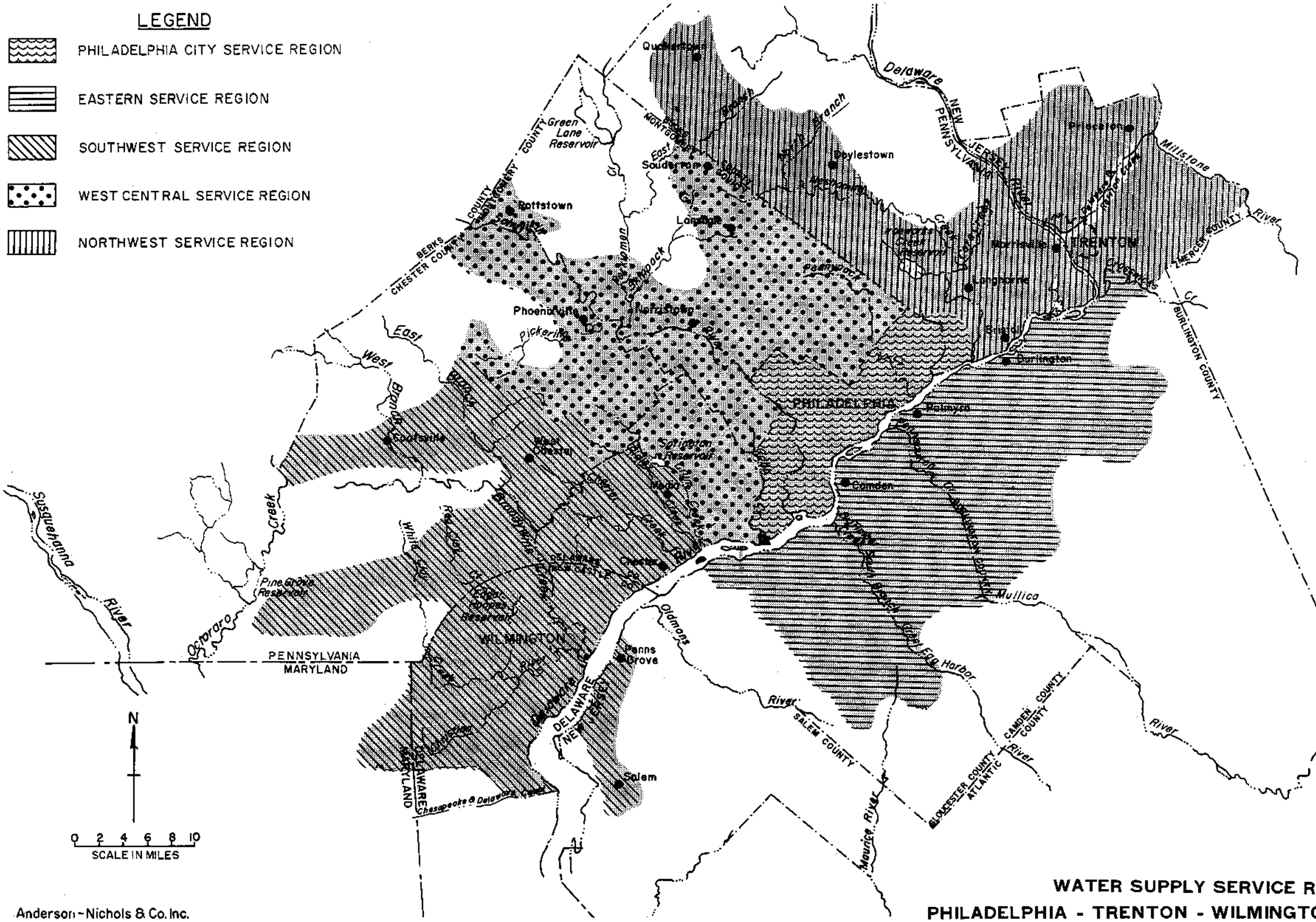
**KNOWN WATER SUPPLIES**
**PHILADELPHIA - TRENTON - WILMINGTON UMA**
**FIGURE 69**

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**WATER SUPPLY SERVICE REGIONS**

**PHILADELPHIA - TRENTON - WILMINGTON UMA**

**FIGURE 70**

TABLE 83

SERVICE REGIONS - POPULATION AND WATER USE 1/

| Service Region | 1980 | 2000 | 2020 |
|---|---|---|---|
| Northwest: Population | 831 | 1,137 | 1,498 |
| Public M & I | 125 | 191 | 303 |
| Self-supplied industry | 205 | 269 | 342 |
| West Central: Population | 1,188 | 1,469 | 1,722 |
| Public M & I | 180 | 247 | 348 |
| Self-supplied industry | 417 | 548 | 696 |
| Southwest: Population | 924 | 1,486 | 2,058 |
| Public M & I | 165 | 292 | 435 |
| Self-supplied industry | 284 | 373 | 474 |
| Philadelphia City: Population | 1,874 | 1,850 | 1,850 |
| Public M & I | 382 | 470 | 592 |
| Self-supplied industry | 593 | 780 | 990 |
| Eastern: Population | 1,060 | 1,369 | 1,670 |
| Public M & I | 148 | 220 | 312 |
| Self-supplied industry | 191 | 251 | 319 |

1/ Population given in 1,000's, water use in mgd (fresh water only).

In the analysis that follows for each of the five service regions, fresh water for cooling nuclear power plants has not been included, because the exact siting of the plants was not available. The Delaware River Basin Commission has made an estimate that the consumptive use of fresh water for power plants will be on the order of 88, 260, and 480 mgd in 1980, 2000, and 2020, respectively.

Northwest Service Region.

The Northwest Service Region is limited to portions of the UMA included in Bucks County, Pennsylvania, and Mercer County, New Jersey. Small portions of lower Bucks County are at present included in the Philadelphia City Service Region and served by the Philadelphia Water Department. However, since the Delaware River is the source common to both regions, the division is not significant. Portions of the UMA in Mercer County are contained within the Raritan River Basin in northern New Jersey, while some western areas are drained by Perkiomen Creek into the Schuylkill River.

The area is drained largely by the main stem of the Delaware River, the major source for this service region, and by Neshaminy Creek. Ground water also supplies some minor water systems in the vicinity.

Explanations and assumptions --

Consumptive use was estimated as 10 percent of the total public M & I and self-supplied industrial water use, with the remaining 90 percent returned as treated sewage effluent.

Required low flow for water quality maintenance has been estimated at 980 mgd as the 7-day low flow with a 10-year recurrence interval. The USGS gage at Trenton, New Jersey, was utilized because the river is tidal below the gage.

Consumptive cooling water requirements for fossil fuel power plants have no substantial effect on the available supply. This statement is invalidated, however, if the DRBC permits the siting of nuclear power plants in the Northwest service region, where fresh water would be used as the coolant. (See p. 271.)

Agricultural and irrigation requirements will be satisfied by private sources, generally of ground water, and should not be expected to have a significant effect on the surface water sources.

Water exported from the Basin, at or just above Trenton, includes: 100 mgd of allocated diversion to the State of New Jersey, in part through the Delaware and Raritan Canal (a past and continuing requirement); 35 mgd average (46 mgd peak) demand for the proposed Limerick nuclear power plant; and another 300 mgd which the State of New Jersey applied for, and is expected to develop, before 2000 (assumed to come from the Tocks Island Project). These exports do not, however, include the diversions from Delaware River headwaters of up to 800 mgd for New York City water supply, based on the 1954 decision of the U.S. Supreme Court.

Analysis of the Northwest Service Region for source and treatment requirements, based on the foregoing explanations, is shown in Table 84. The table further shows that the available flow of the Delaware River, based on its minimum recorded flow at Trenton, is more than adequate to supply all public M & I and self-supplied industrial requirements through the year 2020. However, certain other factors bear on the water supply of this service region:

- Although stream flow is adequate to support water use requirements, augmentation is necessary to meet projected low-flow requirements, which form the de-

TABLE 84

FUTURE SOURCE AND TREATMENT REQUIREMENTS

NORTHWEST SERVICE REGION
(All values in mgd)

| | 1980 | | 2000 | | 2020 | |
|---|---|---|---|---|---|---|
| **Source:** | | | | | | |
| Total M & I | 125 | | 191 | | 303 | |
| M & I Consumption | | 12 | | 19 | | 30 |
| Total Self Supplied Industry | 205 | | 269 | | 342 | |
| Self Supplied Industry Consumption | | 20 | | 27 | | 34 |
| Low-Flow Requirement (est.) | | 980 | | 980 | | 980 |
| Total | | 1,012 | | 1,026 | | 1,044 |
| Total Use | 330 | | 460 | | 645 | |
| Exports from Basin at or just above Trenton, New Jersey (see page 258) | | 135 | | 435 | | 435 |
| Total Required Flow | | 1,147 | | 1,461 | | 1,479 |
| Available Low-Flow (Delaware River minimum day) | | 763 | | 763 | | 763 |
| Required Augmentation | | 384 | | 698 | | 716 |
| **Treatment:** | | | | | | |
| Public M & I | 125 | | 191 | | 303 | |
| Existing Treatment Capacity | 110 | | 110 | | 110 | |
| Treatment Deficit | 15 | | 81 | | 193 | |

sign basis for stream water quality standards. Augmentation is also necessary to maintain adequate water quality for supply within reach of the river, since permits for M & I waste discharges are based on a low-flow requirement. For most purposes, the water quality above Trenton is adequate, but it deteriorates in the tidal portions to the south. The waste discharges are greater in the Camden-Philadelphia area, so the condition of the water depends on a delicate balance among discharge, fresh water in-flow, and tidal movements.

- Localized requirements in the remote portions of the service region may call for plans for extensive pumping or diversion from the Delaware River. In instances where requirements are small, however, ground water may be adequate.

- The current treatment capacity of Table 84 includes the total capacity of the major and minor facilities of the service region.

West-Central Service Region.

The West-Central Service Region includes major portions of the UMA which are drained by the Schuylkill River, and the charter service area of the Philadelphia Suburban Water Company. As can be seen on Figure 70, the northern and western boundaries of the region coincide with the boundaries of Bucks and Philadelphia counties.

Streams supplying the service region include the Schuylkill River, Crum Creek, Pennypack Creek, Perkiomen Creek, Pickering Creek, and minor portions of Neshaminy Creek. The Philadelphia Suburban Water Company currently withdraws Neshaminy Creek water, augmented by upstream storage from Springfield Lake. Although Neshaminy Creek lies in the Northwest Service Region, the water withdrawn from it by the Philadelphia Suburban Water Company is included in the West-Central Service Region.

Explanations and assumptions --

Consumptive use was estimated as 10 percent of the total public M & I and self-supplied industrial water use with the remaining 90 percent returned as treated sewage effluent.

The Schuylkill River is the major source for the West-Central Service Region. The low-flow water quality requirement is about 200 mgd (7-day low-flow with a 10-year recurrence interval). However, the City of Philadelphia has been allocated a maximum withdrawal of 258 mgd from the Schuylkill; therefore, a 258 mgd has been used to meet the low-flow requirement. (See Table 85.) The river is tidal below the City and there are no further downstream requirements at this time.

Agricultural and irrigation requirements are not expected to have a significant effect on the major water sources of the region. Any such requirements will be small, since the region is primarily urban, and can be satisfied by low yielding wells.

Although non-nuclear power plants are expected to have a large demand for cooling water, their actual consumptive use is almost negligible. Nuclear power plants, however, generally consume great amounts of water; if any are eventually sited in the West-Central Service Region, their requirements should be considered. The only nuclear power plant scheduled at present for the region is the Limerick Plant at Pottstown, whose consumptive water use is expected to be 35 mgd. This requirement is included in the Northwest Service Region.

Table 85 shows that only a small portion of actual water use is consumptive. The remainder is returned to the source, available for further use downstream. Reuse of water is a well-accepted fact in this service region, especially within the Schuylkill River Basin. The reuse factors calculated in Table 85, however, consider only public M & I and self-supplied industrial demands, because it is these that, in general, are the most destructive to water quality.

The source requirements for this region have incorporated the concept of reusing water, because projecting future demands only on the basis of a single usage of water would be overly conservative, if not unrealistic. Yet even with reuse, a significant source deficit of 66 mgd is predicted within this service region by 1980. Planning must begin immediately if the deficit is to be prevented.

The water resource situation of the West-Central Service Region presents adequate cause for concern. First, although the consumptive use for water cooling requirements of the power industry is negligible at present, the total amount of water utilized is enormous. Including these requirements in the present analysis would double and triple the projected reuse factors. The water is employed on a "once-through" basis, withdrawn and returned directly to the source at a higher tem-

TABLE 85

FUTURE SOURCE AND TREATMENT REQUIREMENTS

WEST-CENTRAL SERVICE REGION
(All values in mgd)

| | 1980 | | 2000 | | 2020 | |
|---|---|---|---|---|---|---|
| Source: | | | | | | |
| Total M & I | 180 | | 247 | | 348 | |
| M & I Consumption | | 18 | | 25 | | 35 |
| Total Self Supplied Industry | 417 | | 548 | | 696 | |
| Self Supplied Industry Consumption | | 42 | | 55 | | 70 |
| Low-Flow Requirement* | | 258 | | 258 | | 258 |
| Total Use (Excludes Power) | 597 | | 795 | | 1,044 | |
| Total Requirement (Excludes Power) | | 318 | | 338 | | 363 |
| Projected Multiple Use Factor (Excluding power, requirements) | 1.88 | | 2.35 | | 2.88 | |
| Existing Source Development | | 252 | | 252 | | 252 |
| Required Augmentation | | 66 | | 86 | | 111 |
| Treatment: | | | | | | |
| Total M & I | 180 | | 247 | | 348 | |
| Deduct present groundwater capacity | 18 | | 18 | | 18 | |
| | 162 | | 229 | | 330 | |
| Existing Treatment Capacity | 134 | | 134 | | 134 | |
| Required Treatment Capacity | 28 | | 95 | | 196 | |

*Allocation to Philadelphia Water Department.

perature. The consumptive use of water will undoubtedly increase drastically as nuclear power plants are built, and stricter federal regulations on thermal pollution are enforced.

Most pressing, however, is the issue of the quality of Schuylkill River water, since any regional approach to the solution of the water supply problems of the Philadelphia-Trenton-Wilmington UMA must include consideration of the Schuylkill as a major source. Numerous studies have concluded the following points:

- At various times the entire main stem of the Schuylkill River is severely degraded.
- Portions of the main stem within the West-Central Service Region have been degraded from all standpoints -- physical, chemical, bacteriological.
- Any attempt to upgrade stream conditions will require significant amounts of time and money, but immediate action is mandatory.
- The Schuylkill River Basin does not have sufficient runoff to alleviate the problem through streamflow augmentation alone.
- In the lower portions of the main stem, advanced waste treatment of all discharge is required.

The facts and figures for the West-Central Service Region present a very bleak water supply situation. Although the difficulties are well recognized by the DRBC and by local, state and Federal agencies, a plan for regional coordination, with prospects for implementation, is desperately needed.

### Southwest Service Region.

The Southwest Service Region includes major portions of Chester and Delaware Counties, Pennsylvania, and New Castle County, Delaware. Fringes also extend into Maryland (Elkton) and New Jersey (Penns Grove - Salem City). The entire region lies primarily within the Delaware River Basin, except for some western portions that are drained by the Susquehanna River and Chesapeake Bay. Major streams within the service region include Brandywine Creek, Red and White Clay

Creeks, Christina River, Chester Creek, Ridley Creek, and Crum Creek, all in the Delaware River Basin; and the Big and Little Elk Creeks, in the Chesapeake Bay drainage area.

Explanations and assumptions --

Consumptive use was estimated as 10 percent of the total public M & I and self-supplied industrial water use, with the remaining 90 percent returned as treated sewage effluent.

Agricultural and irrigation requirements are shown to have a significant effect on the existing water resources, because these requirements are assumed to be entirely consumptive. The agricultural and irrigation requirement values in Table 86 are based upon figures determined by the Delaware River Basin Commission.

The low-flow requirement for water quality purposes is estimated as the 7-day low flow with a 10-year recurrence interval. The value in Table 86 is the summation of the low-flow requirements for the various streams in the area.

If the actual total water requirement is the sum of the above factors, then the streamflow required for the Southwest Service Region is less than its actual water use. The streamflow is being used a number of times before emptying into the Delaware River; the reuse of water is an established fact within the service region.

Table 86 indirectly presents assumptions made in determining the actual source requirements for the Southwest Service Region:

The required flow includes all consumptive uses, plus the water quality low-flow requirement.

Sixty mgd of Susquehanna Basin water, used mainly in the Oxford and Chester City areas, have been deducted from the total water use. Multiple use of this water is not possible, because the Oxford area drains to the Susquehanna River (outside the Service Region), and the city of Chester discharges its effluent directly into the Delaware River below any other intakes.

When requirements are based solely on consumption and low flow, the projected multiple use can be determined by dividing the resulting figures by the required low flow. The result shows that the entire streamflow will be used more than 4.5 times by the year 2020. Yet even with high reuse factors, a 23 mgd deficit will occur by 1980, and will increase to 84 mgd by 2020.

## TABLE 86

### FUTURE SOURCE AND TREATMENT REQUIREMENTS

### SOUTHWEST SERVICE REGION
(All values in mgd)

| | 1980 | | 2000 | | 2020 | |
|---|---|---|---|---|---|---|
| **Source:** | | | | | | |
| Total M & I | 165 | | 292 | | 435 | |
| M & I Consumption | | 17 | | 29 | | 44 |
| Total Self Supplied Industry | 284 | | 373 | | 474 | |
| Self Supplied Industry Consumption | | 28 | | 37 | | 47 |
| Agricultural - Irrigation | 19 | | 26 | | 34 | |
| Consumption | | 19 | | 26 | | 34 |
| Low-Flow Requirement | | 68 | | 68 | | 68 |
| Required Flow | | 132 | | 160 | | 193 |
| Total Use | 468 | | 691 | | 943 | |
| Deduct Chester Water Authority | 60 | | 60 | | 60 | |
| | 408 | | 631 | | 883 | |
| Projected Multiple Use Factor | 3.1 | | 3.9 | | 4.6 | |
| Existing Sources | | 109 | | 109 | | 109 |
| Required Augmentation | | 23 | | 51 | | 84 |
| **Treatment:** | | | | | | |
| Total M & I | 165 | | 292 | | 435 | |
| Deduct Groundwater Capacity | 26 | | 26 | | 26 | |
| | 139 | | 266 | | 409 | |
| Existing Treatment Capacity (ave.) | 176 | | 176 | | 176 | |
| Required Treatment Capacity | - | | 90 | | 233 | |

Treatment deficits were based on average day demands and average capacities. The present ground water capacity of 26 mgd was deducted so that only surface water would be considered. Existing treatment capacity includes both major and minor systems in the region.

Three major factors should be considered when interpreting the projected deficits for the Southwest Service Region. The first concerns the relative location of demand centers to sources of supply. A stream's safe yield was based on its entire drainage area. Since the area and, consequently, the safe yield of streams, is much less in the northern portions of the service region, localized deficiencies in supply already exist.

The second concerns excess treatment capacity for the cities of Wilmington and Chester, which has offset localized deficits in other portions of the region. Localized areas in the northern and suburban sections of the region also may be experiencing treatment shortages and could soon experience source shortages, if drought conditions should recur. It has not been practical in this preliminary study to delve into these localized problems; a feasibility study of the region, however, should definitely investigate this critical situation.

The third major concern is that of water quality. Conventional secondary treatment of sewage is generally the rule within the service region, although primary treatment still exists in some areas along the Delaware River. With the high reuse factors projected in Table 86 , water quality must be monitored closely. The cumulative effects of certain contaminants, such as the heavy metals and enteric viruses, which are not removed by conventional treatment, should be thoroughly investigated. In all probability, additional flow augmentation will be required to accomodate municipal and industrial discharges, thereby increasing the water supply requirements. However, flow augmentation is not a panacea: advanced waste treatment as a standard requirement may be the only recourse.

Philadelphia City Service Region.

The Philadelphia City Service Region is limited to the city of Philadelphia and small portions of southern Bucks County, Pennsylvania, coinciding with the service area of the Philadelphia Water Department.

The Delaware River Basin Commission has given the city a maximum allocation of 258 mgd from the Schuylkill River, and 432 mgd from the Delaware River. Since the source requirements of the Schuylkill River are discussed under the West-Central Service Region and shown in Table 85 (p. 271-2), the low-flow augmentation necessary to provide the 258-mgd allocation has been considered already.

It is estimated that withdrawals from the Schuylkill for the service region will average about 200 mgd or less, with peak withdrawals up to the maximum allocation. The remaining portion of the total M & I demand will be withdrawn from the Delaware River, which is a tidal waterway up to the head of navigation at Trenton, New Jersey. In this reach, therefore, the river behaves essentially as a large fresh-water reservoir whose salt water interface follows the tidal fluctuations.

TABLE 87

FUTURE TREATMENT REQUIREMENTS

PHILADELPHIA CITY SERVICE REGION

| | 1980 | 2000 | 2020 |
|---|---|---|---|
| Public M & I Demand (mgd) | 382 | 470 | 592 |
| Existing Treatment Capacity (mgd) | 480 | 480 | 480 |
| Required Treatment Capacity (mgd) | -- | -- | 112 |

Table 83, p. 257, presented the total M & I and self-supplied industrial water requirements for the Philadelphia City Service Region. If 10 percent is assumed to be used consumptively, then the actual water consumption for this service region becomes 98 mgd in 1980, 125 mgd in 2000, and 158 mgd in 2020. With the consumptive water use of 64 mgd of the Northwest Service Region, the total value for 2020 is 222 mgd. This total could be withdrawn from the Delaware River, because the record one-day low flow of 763 mgd at Trenton is adequate to supply the amount; however, this does not consider the salt front problem discussed on p. 268.

Table 87 indicates that the existing treatment capacity of the Philadelphia City Service Region should be adequate to meet the average demands until sometime after 2000. The system may have difficulty in meeting peak demands even before then, however; and it is fairly certain that both average and peak treatment capacities will have to be increased by 2020. It is not the available quantity of water that is the problem, however; it is the quality of water.

Water quality problems of almost every conceivable nature plague the lower portions of the Delaware River during periods of low flow, for two reasons: first, large municipal and industrial discharges have degraded water quality; and second, salt-water contamination endangers the Torresdale intakes of the Philadelphia Water Department.

The M & I discharges have accounted for the depletion of dissolved oxygen content; the dangerously low pH levels, causing water to become acidic; increases in water temperatures; and a hazardous coliform count. Water at the Torresdale intake has been rated as a poor source, and in need of auxiliary treatment; and yet portions of the river as far south as the Walt Whitman Bridge have been zoned by the DRBC for use as a public water supply. Stricter regulation of discharges of the increasing population and industry must be effected, if an acceptable quality of water is to be made available.

Perhaps the main concern of the Philadelphia City Service Region is to prevent salt-water contamination of the Torresdale intakes during periods of low flow. The fresh-water flow of the upper Delaware River into the tidal portions controls the location of chloride concentrations in the lower reaches of the river. The U.S. Public Health Service recommends a maximum concentration of 250 mg/l, although even lower levels, which are troublesome for certain industries, can be detected by some individuals. Levels as high as 95 mg/l and 150 mg/l have been reported, respectively, at the Tacony-Palmyra Bridge 3.6 miles downstream from Torresdale, and at the Ben Franklin Bridge, 10 miles downstream. Lower portions which have been zoned for water supply will probably contain even higher chloride concentrations.

The DRBC has estimated that a flow of 3,000 cfs (1940 mgd) at Trenton is required to maintain a chloride concentration of 250 mg/l at the mouth of the Schuylkill River, under the most severe drought conditions of record. This flow was determined for the drought of record (1960's) by use of mathematical and physical models of the Delaware River Basin at the U.S. Army Corps of Engineers, Waterways Experiment Station in Vicksburg, Mississippi. Assurance of this flow would guarantee Philadelphia's water allocation, and would enhance greatly the quality of the tidal portions, thus creating water supply opportunities for deficient areas of the entire UMA. It is obvious, therefore, that a 3,000-cfs flow is needed at Trenton to supply the Philadelphia-Trenton-Wilmington UMA adequately.

Eastern Service Region.

The Eastern Service Region, as shown on Figure 70, is located southeast of the Delaware River, and lies entirely in the State of New Jersey. The region includes portions of Burlington, Camden, and Gloucester counties, and drains to the Delaware River through a number of small streams and rivers.

The total M & I and self-supplied industrial demands are presented in Table 83, p. 257. The Eastern Service Region is the only one in the UMA to be served entirely from ground water sources; multiple use, or reuse, of water is not evident. Municipal and industrial wastes are discharged to the area streams that, in general, flow directly to the Delaware River. A small portion of the discharge probably seeps into the substrata and recharges aquifers in the region, but an in-depth investigation would be required to determine the amount. During dry-weather periods, the reverse situation occurs: the aquifers will actually contribute a portion of the stream flow.

Explanations and assumptions --

The total water requirement of public systems is the total M & I water demand employed on a "once-through" basis; i. e., multiple use of water was not considered.

Self-supplied industrial water was also considered for its fresh water demand on the total available ground water sources. A certain unknown portion of this demand will be satisfied from the Delaware River.

Existing system capacity includes both the major systems of the service region, and the combined capacity of a large number of minor systems that amounts to 36 mgd.

Capacity and requirements have not been disaggregated according to source and treatment, for three reasons: First, treatment is not usually required for ground water supplies, except in localized areas with problems of iron and/or manganese contamination. Second, well yield, pumping, and transmission capacities are generally closely related:

pump capacity is sized to the developed well yield. Third, the total safe yield of the aquifers is unknown, but estimated to be very large. A single value of the water system capacity, therefore, is adequate to describe the water resources development of the region.

Table 88 presents the water systems requirements for the Eastern Service Region. The values therein show that a requirement of 8 mgd will occur by 1980, and will increase to 172 mgd by 2020. The requirement does not reflect a shortage in source supply or available treatment capacity, however; it is, rather, the amount of water, over and above the existing system capability, which must be supplied, treated as necessary, and delivered to the distribution systems by the benchmark years. Considering the ease of development and the availability of ground water for this service region, the system requirements are not regarded as critical for the immediate future. However, if the 2020 requirement of 172 mgd cannot be supplied readily from aquifers within the region which are recharged by normal precipitation and stream flow, then recharge from collected storm water runoff or treated wastewater should be considered. Other possibilities for supplemental supply include diversion of surface or ground water from outside the service region.

TABLE 88

FUTURE SOURCE REQUIREMENTS

EASTERN SERVICE REGION
(All values in mgd)

| | 1980 | 2000 | 2020 |
|---|---|---|---|
| Public M & I Demand | 148 | 220 | 312 |
| Self-supplied Industrial Demand | 191 | 251 | 319 |
| Total Supply Required | 339 | 471 | 631 |
| Existing System Capacity | 140 | 140 | 140 |
| Public System Requirement | 8 | 80 | 172 |

Table 89 summarizes deficits and consumptive water use within, and diversions of fresh water from, the Philadelphia-Trenton-Wilmington UMA. The different groupings are necessary to reflect an accurate representation of the problems, and the time phasing necessary to eliminate them.

The city of Philadelphia has no source deficit, but its treatment plant capacity must be expanded. It must also insure that the salt water barrier remains sufficiently far downstream.

TABLE 89

CONSUMPTIVE USES, DIVERSIONS, AND DEFICITS
PHILADELPHIA-TRENTON-WILMINGTON UMA
(All values in mgd)

| Category | Service Region | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Consumptive Uses (within UMA excluding power) | Northwest | 32 | 46 | 64 |
| | West Central | 70 | 80 | 105 |
| | Southwest | 64 | 92 | 125 |
| | Philadelphia City | 98 | 125 | 158 |
| | Eastern | 34 | 47 | 63 |
| | Total | 298 | 390 | 515 |
| Consumptive Use (Power) 1/ | | 88 | 260 | 480 |
| Diversions at or just above Trenton (Out of UMA) | Northwest | 135 | 435 | 435 |
| Treatment Plant Capacity Deficit | Northwest | 15 | 81 | 193 |
| | West Central | 28 | 95 | 196 |
| | Southwest | -- | 90 | 233 |
| | Philadelphia City | -- | -- | 112 |
| | Total | 43 | 266 | 734 |
| Ground Water Development Deficit | Eastern | 8 | 80 | 172 |
| Stream-Flow Deficit 2/ (Excludes Power) | Northwest | 384 | 698 | 716 |
| | West Central | 66 | 86 | 111 |
| | Southwest | 23 | 51 | 84 |
| | Total | 473 | 835 | 911 |

1/ Estimates furnished by DRBC for entire Delaware River Basin (compare area of basin, 12,765 sq. mi. to area of UMA, 2,640 sq. mi.)

2/ Includes the estimated stream water quality requirements for these service regions.

Consumption of fresh or brackish water, either upstream or downstream of the UMA, will affect the salt front. Therefore, the consumptive uses of power plants for which construction has been approved were considered in developing a stream-flow balance for the Delaware River Basin and the UMA. Approvals for future constuction of power plants will require further consideration of the fresh-water balance. If future construction is approved that permits appreciable consumption anywhere in the Basin, additional sources of fresh water must be provided to balance additional consumption.

The Eastern Service Region must increase its ground water development, while the Northwest, West Central, and Southwest Service Regions require additional surface water development. Low flow augmentation will not only serve to meet consumptive water needs, but will also help to stabilize the salt barrier, a primary concern of Philadelphia and, perhaps, of the Eastern Service region.

## DESIRABILITY FOR REGIONALIZATION

### Philadelphia City Service Region

The analysis of the water supply systems and service regions in the Philadelphia-Trenton-Wilmington UMA has demonstrated that the Philadelphia City Service Region is better equipped to meet future demands than any of the other service regions. Except for the small portions of lower Bucks County, the entire service region is under one governmental authority, the city of Philadelphia, but it is the only region to be so united. As a result, the problems peculiar to this area almost dictate a regionalized approach beyond the service region boundaries.

Water quality and streamflow problems are common to both the Delaware and Schuylkill Rivers, which supply the region. One solution to this would be low-flow augmentation, but the Philadelphia Service Region alone does not have the economic capability to provide it. Furthermore, a drought severe enough to cause salt-water contamination of the Torresdale intakes is an ever-present possibility. The resultant water shortage in such a large metropolitan area could have economic and social ramifications on a regional, if not a national, level. Regionalization beyond the present service area could provide the financial resources and the authority required to insure adequate water quality of its sources.

### Eastern Service Region

The Eastern Service Region seems to be the least adaptable to any physically regionalized water system in the immediate future. The availability of vast ground water resources in this area, and their economic advantages over surface supplies, have resulted in the establishment of over 50 water systems serving the region, only 4 of which are major systems. Although this piecemeal development has apparently proved adequate in the past, problems may arise in the future: excessive draw-down of the water table, localized areas of contamination, and possible salt-water intrusion.

The State of New Jersey currently regulates ground water withdrawals; but regulation should be accompanied by a greater system of test and observation wells to monitor closely water-table levels and water quality. If water demands approach the capability of underlying aquifers, then the alternatives available to the service region are several: recharge of the ground water aquifers from storm-water runoff or treated wastewater; pumping and treatment of Delaware River Water; interconnections of water systems and importation of ground water from aquifers outside the UMA; or interconnections and importation of surface water outside the UMA.

It is obvious that these alternatives would require a regional approach. Consequently, while a regional water supply system is not required immediately, future conditions may warrant its establishment. Regionalization of planning is, therefore, highly desirable.

### Southwest Service Region

The Southwest Service Region includes portions of five counties in four different states, and is supplied primarily from surface sources, with some ground water sources in the Delaware portion. Considering that the major streams of the region, the Brandywine, Red Clay and White Clay Creeks, cross county and state boundaries, a regional system unhindered by political confines would most efficiently utilize the water resources. To some extent, regionalization has been approached, since many of the systems in northern Delaware have emergency interconnections in case of drought or other unusual conditions. The remainder of the region has generally followed the conventional piecemeal development of the resources, with only two major systems serving the area.

Regionalization in the Southwest Service Region would be desirable for a number of reasons. The available resources could be distributed more uniformly to prevent localized areas of shortage. As the demands increase, ground and surface sources could be developed extensively, yet economically. Economy would be true also of treatment, pumping and transmission facilities, and additional sources. Inter-basin transfers, if necessary, would be more adaptable to regulation by some type of regional authority. The high reuse factors projected for this service region would suggest that a regional water quality management program would be desirable. As in the case of the Eastern Service Region, regionalization through planning is desirable.

### West-Central Service Region

Many of the difficulties facing the West Central Service Region are similar to those of the Southwest Service Region: water quality, reuse, and flow augmentation are acute problems. Numerous studies of the Schuylkill River, the primary source for the region, have concluded that flow augmentation, along with strict water quality regulation and enforcement, is mandatory. Furthermore, inter-basin transfer will be needed, because the basin's capacity of development will not suffice to meet demands. Obviously, a regional approach is needed to insure an adequate quantity of water at an acceptable level of quality to satisfy the people and industries of the region.

### Northwest Service Region

The Northwest Service Region, containing portions of Bucks County, Pennsylvania, and Mercer County, New Jersey, depends principally on the Delaware River and a few ground water sources for its supply. Since the service region crosses state boundaries and uses an interstate river for its water demands, some regional authority is needed. Economies of scale not available to individual counties would emphasize the desirability of a regional system.

### Summary

The present study has shown that regionalization would appear to be beneficial for the entire UMA. It is for further feasibility studies, however, to determine the exact level of regionalization, the consolidating of the various regions, and the functions and responsibilities of a regional authority.

Engineering and hydrologic considerations have led to the following generalizations about the Philadelphia-Trenton-Wilmington area:

- It would be undesirable, and probably unrealistic, to serve the entire UMA from a single source - the Delaware River.

- The entire UMA could probably be served from developable sources entirely within the Delaware River Basin. However, inter-basin transfers of ground or surface water may prove to be more economical.

- Regionalization of water supply for the UMA would employ the current planning framework of the Delaware River Basin Commission and the Delaware Valley Regional Planning Commission. The DRBC must be fully involved in a move toward regionalization, because satisfaction of the water demands of the Philadelphia-Trenton-Wilmington area will require the resources of the entire Delaware River Basin.

- The Eastern Service Region should continue to develop ground water sources until the capacity of the aquifers within the UMA is fully allocated. If additional sources are required, alternatives would include recharge of the ground-water aquifers from storm water runoff or treated wastewater, importation of ground water into the UMA, or direct pumping and treatment of Delaware River water.

## DEVELOPMENT ALTERNATIVES

### Objectives

The objectives of water resource development which follow are based upon the findings of previous sections. Satisfaction of the objectives should preclude any shortcomings in source development for the entire Philadelphia-Trenton-Wilmington UMA through the year 2020.

- The Delaware River Basin should be developed as necessary, in order to guarantee a flow of at least 3,000 cfs in the Delaware River at Trenton, New Jersey. Maintenance of this minimum flow would prevent the 250 isochlor (chloride concentration of 250 milligrams per liter) from advancing past the mouth of the Schuylkill River at Philadelphia. Assurance of the flow would guarantee allocation to the Philadelphia City Service Region, and would satisfy low-flow augmentation requirements for the Northwest Service Region of 384, 698, and 734 mgd for the years 1980, 2000, and 2020, respectively.

- Quantities of water on the order of 8, 80, and 172 mgd should be made available to the Eastern Service Region before the years 1980, 2000, and 2020, respectively.

- Quantities of water on the order of 23, 51, and 84 mgd should be made available to the Southwest Service Region before the years 1980, 2000, and 2020, respectively.

- Quantities of water on the order of 66, 86, and 111 mgd should be made available to the West Central Service Region before the years 1980, 2000, and 2020, respectively.

### Potential Sources of Supply

Federal, State, and local agencies, including the DRBC, have proposed a multitude of water resource development projects in the Delaware River Basin for, among other reasons, satisfying future water supply requirements in the Philadelphia-Trenton-Wilmington UMA. The projects are represented graphically on Figure 71, and summarized in Table 90, p. 286.

Prompton Reservoir Modification Project.

The Prompton Reservoir Modification Project has been proposed by the U. S. Army Corps of Engineers for construction on the Lackawaxen River, a tributary to the upper Delaware River. The multi-purpose reservoir would have a contributing drainage area of 60 square miles, impound 9.1 billion gallons for long-term storage, and have a safe yield of 37 mgd for water supply.

Cost estimates of about $8.5 million have been made. The reservoir modification is to be constructed when considered economically justifiable.

Tocks Island Project.

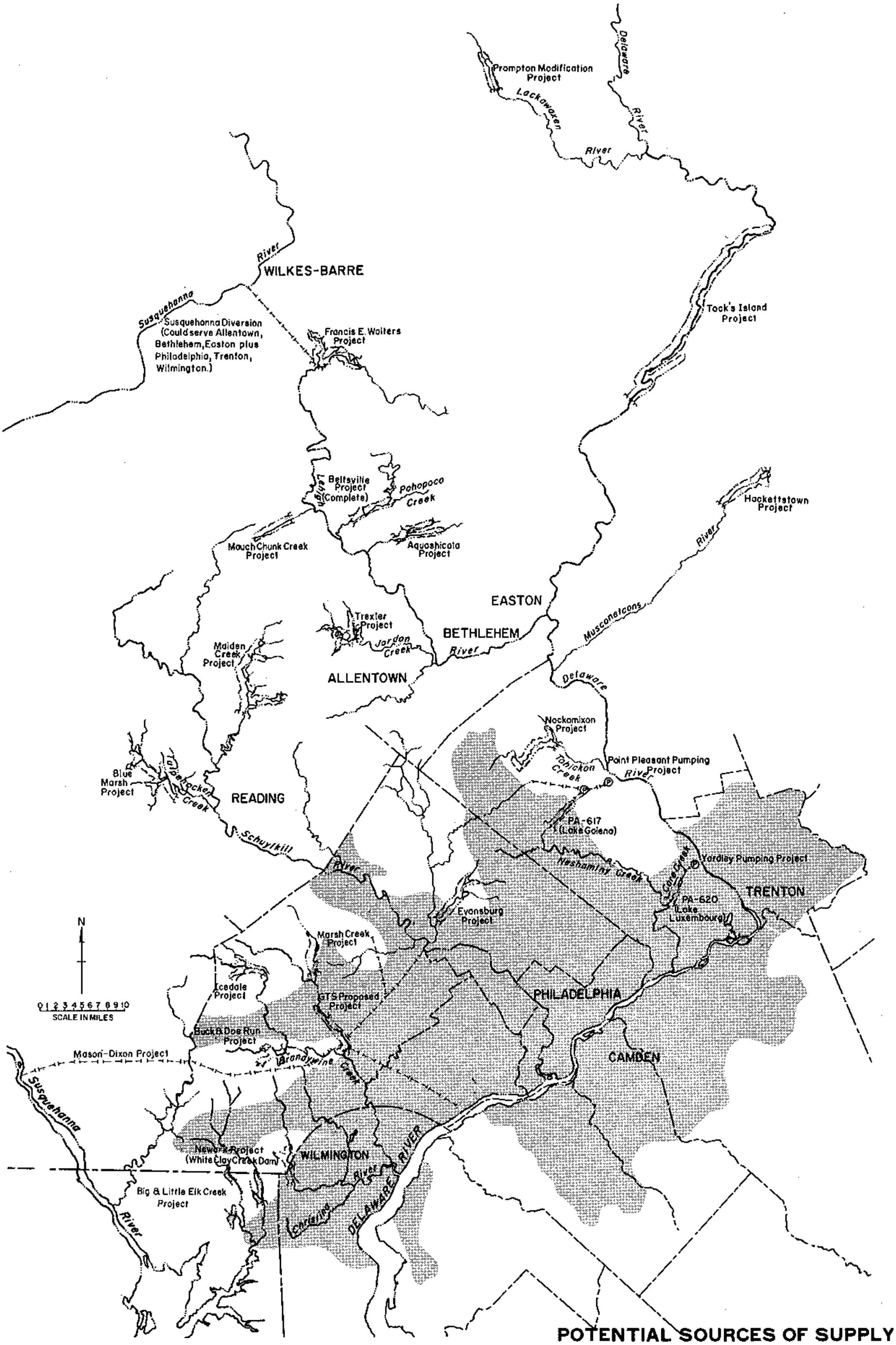
The Tocks Island Project has been authorized by Congress for construction by the U.S. Army Corps of Engineers. While the Delaware Water Gap National Recreational Area, which is associated with the project, is partially completed and open to the public, the Corps is still acquiring land for the reservoir. The multi-purpose reservoir, located on the main-stem Delaware, will contribute to water supply needs, flood control, power requirements, and water-based recreation in the Delaware River Basin.

The reservoir will have a total storage capacity of over 275 billion gallons, of which 139 billion gallons will be active, long-term storage. With a contributing drainage area of 2,912 square miles, the reservoir is expected to have a safe yield available for water supply of 633 mgd. The reservoir will employ the principle of low-flow augmentation: it will release water during low-flow periods and store water otherwise.

The $250 million project is tentatively scheduled for completion in 1978. However, a study currently investigating the environmental impact of the project, could delay or even prevent its completion. The Tocks Island Project is the most feasible from an economic and engineering standpoint in helping to solve the water supply problems of the UMA.

Francis E. Walters Modification Project.

The Francis E. Walters Modification Project has been proposed




POTENTIAL SOURCES OF SUPPLY
PHILADELPHIA-TRENTON-WILMINGTON UMA
FIGURE 71

for construction on the Lehigh River by the U.S. Army Corps of Engineers. The multi-purpose reservoir would contribute to water supply needs, flood control, and water-oriented recreation.

The reservoir would have a total storage capacity of 58.7 billion gallons, of which 22.8 billion gallons would be used for active, long-term storage. With a drainage area of 288 square miles above the reservoir, a safe yield of 126 mgd could be expected.

The $9 million project would be constructed when economically justifiable.

Mauch Chunk Creek Project.

A reservoir on Mauch Chunk Creek, a tributary to the Lehigh River, has recently been completed. The multi-purpose reservoir is used for flood control, recreation, and as an emergency storage reservoir for Jim Thorpe borough. The reservoir is relatively small, with a contributing drainage area of slightly less than 6 square miles, and an active long-term storage capacity of 1.4 billion gallons.

Beltzville Project.

Beltzville Reservoir has been constructed by the Corps of Engineers. Water from its contents represents the first actual sale of water by the Delaware River Basin Commission. The multi-purpose reservoir, located on Pohopoco Creek, a tributary to the Delaware River, will contribute to water supply, flood control, and recreational needs.

The reservoir has a total storage capacity of 22.2 billion gallons, of which 9.2 billion gallons will be allocated to water supply. With a drainage area above Beltzville Dam of 75 square miles, the reservoir is expected to have a safe yield available for water supply of 52 mgd. The reservoir, like the proposed Tocks Island reservoir, will employ the principle of low-flow augmentation.

Aquashicola Project.

A reservoir has been proposed on Aquashicola Creek, a tributary to the Lehigh River. Sponsored by the U.S. Army Corps of Engineers, the multi-purpose reservoir would provide water supply, flood control, and water-oriented recreation.

The reservoir would have a contributing drainage area of 66 square miles, impound nearly 8 billion gallons of active long-term storage, and have a safe yield of 41 mgd for water supply.

Cost estimates on the order of $19 million have been made for the project, which would be constructed when economically justifiable.

Trexler Project.

The Trexler Reservoir, to be located on Jordon Creek, a tributary to the Lehigh River, has been proposed and designed by the U. S. Army Corps of Engineers, and has been given final approval for construction by the Delaware River Basin Commission. The multi-purpose project would provide water supply, flood control, and recreation.

The reservoir would have a total storage capacity of 17. 7 billion gallons, of which 13 billion gallons would be available for long-term storage. With a contributing drainage area of 51 square miles, a safe yield of 31 mgd is expected for this reservoir.

Construction costs on the order of $20 million are expected for this project. The time of construction for the reservoir will probably be dictated by public water demands in the Allentown area. (See Chapter 19.)

Hackettstown Project.

Hackettstown Reservoir has been proposed by the State of New Jersey on the Musconetcong River, a tributary to the Delaware River. The reservoir would be used for water supply and water-oriented recreational purposes.

The reservoir would have a total storage capacity of 9. 9 billion gallons, nearly all of which would be available for active, long-term storage. With a contributing drainage area above the site of 70 square miles, a safe yield of 40 mgd could be available for water supply under the drought conditions of the 1960's.

Although the project has been given final approval by the Delaware River Basin Commission, it is anticipated that construction will be deferred beyond 1976 until a need for additional water for augmentation in the Musconetcong Valley and Delaware River develops.

Nockamixon Project.

The Nockamixon dam and reservoir project, located on

Tohickon Creek, a Delaware River tributary, is under construction by the Pennsylvania Department of Forests and Waters. While the initial use of the reservoir will be only recreational, at some future date it may be needed and used as a source of water supply.

The reservoir will provide approximately 10 billion gallons of active, long-term storage. With a drainage area of 75 square miles, a safe yield of 40 mgd is estimated. Construction costs on the order of $15 million can be expected.

Point Pleasant Pumping Project - Lake Galena.

A reservoir on the North Branch of Neshaminy Creek, augmented by water diverted from the Delaware River at Point Pleasant, has been proposed by the Pennsylvania Department of Forests and Waters and the U.S. Soil Conservation Service. The multi-purpose reservoir, Lake Galena, would contribute to flood control, recreation, and supply needs in Bucks and Montgomery Counties, Pennsylvania.

The reservoir would have a total storage capacity of 3.3 billion gallons, of which 1.6 billion gallons would be available for active, long-term storage. With a drainage area of 15.8 square miles above the dam site, only a modest safe yield of approximately 3 to 4 mgd could be obtained from natural runoff. However, acting essentially as an off-stream storage reservoir, augmented with Delaware River water, the safe yield of the reservoir would be governed by the amount of water diverted.

Some of the water from the Beltzville and Tocks Island Reservoirs would probably be allocated to this diversion, which would eventually be capable of providing approximately 120 mgd for water supply. The plan also includes conveyance of water to meet the needs through 2020 of a planned nuclear power plant in Montgomery County.

The project is tentatively scheduled for operation in 1973, although construction has not as yet been started.

Yardley Pumping Project - Lake Luxembourg.

This project is similar to the Point Pleasant Pumping Project, and would entail diversion of water from the Delaware River at Yardley to the headwaters of Core Creek, a tributary to Neshaminy Creek. A reservoir on Core Creek, Lake Luxembourg, would serve the multiple purposes of flood control, recreation, and storage for water supply. The system would call for future diversions on the order of 75 mgd during periods of low flow.

With preliminary work underway at present, the system is expected to be in operation in 1974.

Maiden Creek Project.

A reservoir on Maiden Creek, a tributary to the Schuylkill River, has been proposed by the U.S. Army Corps of Engineers. The multi purpose reservoir would contribute to water supply needs, as well as flood control and water-based recreation.

The reservoir would have a contributing drainage area of 161 square miles, impound 24.1 billion gallons of active, long-term storage, and have a safe yield of 87 mgd for water supply.

Cost estimates on the order of $28 million have been made for the project, which would be scheduled for construction whenever economically desirable.

Blue Marsh Project.

Blue Marsh Reservoir has been proposed by the Corps of Engineers on Tulpehocken Creek, a Schuylkill River tributary. The multi-purpose reservoir would provide water supply, flood control, and recreation.

The reservoir would have a total storage capacity of 16.3 billion gallons, of which 4.8 billion gallons would be available for active, long-term storage. With a drainage area of 175 square miles above the site, it has been estimated that a safe yield of 45 mgd could be obtained for water supply.

The $25-million project has been approved by the DRBC, and was scheduled to begin construction by 1972 and to be completed by 1975. Much of the water from this project will probably be allocated to municipalities in the Reading area. (See Chapter 20.)

Evansburg Project.

The Evansburg Project is presently being developed by the Pennsylvania Department of Forests and Waters. A dam on Skippack Creek, a tributary to the Schuylkill River, will create the multi-purpose reservoir. The reservoir will serve recreational functions initially, but may be needed in future years for water supply.

The reservoir will have a total storage capacity of 8.1 billion gallons, of which 7.5 billion gallons will be available for active, long-term storage. It has been estimated that a safe yield of 23 mgd could be obtained from the 54-square-mile watershed. The projected cost of a two-stage project is $23.8 million.

Marsh Creek Project.

A reservoir has been proposed on Marsh Creek, a tributary to Brandywine Creek. The multi-purpose reservoir would contribute to water supply needs in water-short Chester County, Pennsylvania, as well as flood control, recreation, water quality, and fish and wildlife.

The $6-million project has been approved by the Delaware River Basin Commission and is in the incipient stages of construction. It will have a total storage capacity of 5.6 billion gallons, 4.4 billion gallons of which will be used as active, long-term storage. With a drainage area of approximately 20 sq. miles above the site, a safe yield of 12 mgd is expected from the project.

Icedale Project.

The Icedale Project would include a multi-purpose reservoir on West Branch Brandywine Creek. The reservoir would have a contributing drainage area of 20.2 square miles, impound 4.8 billion gallons for water supply, and have a safe yield of 13 mgd.

The project, with estimated construction costs on the order of $7.5 million, is sponsored by the Pennsylvania Department of Forests and Waters, and the U.S. Soil Conservation Service. The Project is not scheduled for construction at present

Geo-Technical Services Proposed Project.

This project, on East Branch Brandywine Creek, just above its confluence with West Branch, would contain 4.3 billion gallons of water supply storage. With a drainage area of 126 square miles above the site, it is estimated that a safe yield of 45 mgd would be provided. The project has been proposed by Geo-Technical Services (GTS), Consulting Engineers and Geologists, Harrisburg, Pennsylvania.

Buck and Doe Run Project.

A reservoir on Buck and Doe Runs, tributaries to Brandywine Creek, has been proposed by GTS as a means of obtaining water for

Chester County, Pennsylvania. The net contributing drainage area above the site is about 50 square miles. A reservoir, with an active, long-term storage capacity of 10.0 billion gallons, is expected to be capable of yielding 32.5 mgd during drought periods.

Newark Project (White Clay Creek Dam).

A potential reservoir site is under study on White Clay Creek, a tributary to the Delaware River. Sponsored by New Castle County, Delaware, the reservoir would provide water-oriented recreation, as well as water supply.

The reservoir would have a total storage capacity of 10.1 billion gallons, of which 9.8 billion gallons would be available for active, long-term storage. With a drainage area of 67 square miles, a safe yield of 28 mgd could be obtained for water supply.

The $15-million project has been given final approval for construction by the Delaware River Basin Commission.

Big and Little Elk Creeks Project.

Big and Little Elk Creeks Project is a small watershed development now ongoing under the provisions of PL 83-566. Three structures, all located in Cecil County, Maryland, would provide a total of nearly 35,000 acre-feet of storage for the multipurposes of flood control, sedimentation, water supply, fish and wildlife improvement, and recreation. About 9,300 acre-feet of the storage would be allocated to water supply, with an estimated safe yield of 15 mgd for the Elkton area. Total cost of the project is estimated to be about $8.3 million.

Susquehanna River Diversions.

Susquehanna-Lehigh Diversion -- Water from the Susquehanna River could be diverted from the vicinity of Wilkes-Barre to the headwaters of the Lehigh River near Bear Creek Reservoir. This would entail about 12 miles of tunneling through the Penobscot and Nescopeck Mountain and pumping against an elevation of approximately 1,000 feet. This possible project has not been the subject of any known study, but does represent an additional opportunity.

Mason-Dixon Project -- A large-scale inter-basin transfer of water, from the Susquehanna River Basin to adjacent portions of the Potomac and Delaware River Basins, has been proposed by the Mason-Dixon Task Force, Inc., a tri-state agency representing water supply interests in several Delaware, Maryland and Pennsylvania counties.

The Mason-Dixon Project originally included a diversion of "new" water from a reservoir constructed on Conewango Creek, and the Corps of Engineers' multipurpose Raystown Project. Since 300 mgd was assumed to be available, an eastward inter basin diversion of 150 mgd was proposed to serve the lower Susquehanna and Delaware Basin Communities. A similar amount was to be diverted westward to upper tributaries in the Potomac Basin. Later direct diversion to particular areas and intrabasin diversions were considered.

When the costs of water supply features in the reservoirs are included, local alternatives are indicated to be more economical than inter-basin transfers from the Susquehanna or the Delaware Basins. However, some aspects of these plans may be viewed as possible future extensions or modifications of plans for Susquehanna regions, such as the Harrisburg-Lancaster-York area.

System analysis performed in conjunction with the Susquehanna Basin Study, and assuming completion of the Raystown Project, indicated critical flows into the Chesapeake Bay. Thus, with the assumed completion of only those projects presently planned, it appears there would be no Susquehanna River water available for water supply.

Full consideration of the legal, political, economic, and ecologic aspects would be required for any diversion from the Susquehanna River.

Pipeline Diversion along U.S. Route 40 -- Diversion of Susquehanna River water for the northeast and Elkton area of Maryland is possible. Such a diversion would require the installation of an intake, pumping plant, and about 16 miles of pipeline from Havre de Grace to Elkton, along U.S. Route 40.

Desalting.

At the present time, this method is not among the more desirable means of providing public water to the Philadelphia-Trenton-Wilmington UMA, because of the high cost and the number of other opportunities available for water supply development. However, in the future, as technology advances and less expensive processes are realized, desalting may be justifiable and desirable, especially in the southern portion of the area. A further discussion on desalting is presented in Chapter 5, Volume I.

TABLE 90

POTENTIAL SOURCES OF SUPPLY

PHILADELPHIA-TRENTON-WILMINGTON UMA

| Project | Safe Yield for Water Supply (mgd) | Estimated Cost ($millions) |
|---|---|---|
| Prompton Reservoir Modification | 37 | 8.5 |
| Tocks Island | 633 | 250.0 |
| F.E. Walters Modification | 126 | 9.0 |
| Mauch Chunk Creek | Storage | |
| Beltzville | 52 | 13.8 |
| Aquashicola | 41 | 19.0 |
| Trexler | 31 | 20.0 |
| Hackettstown | 40 | 28.0 |
| Nockamixon | 40 | 15.0 |
| Point Pleasant | Variable (diversion) | |
| Yardley | Variable (diversion) | |
| Maiden Creek | 87 | 28.0 |
| Blue Marsh | 45 | 25.0 |
| Evansburg | 23 | 23.8 |
| Marsh Creek | 12 | 6.0 |
| Icedale | 13 | 7.5 |
| GTS Reservoir | 45 | |
| Buck and Doe Run | 32.5 | |
| Newark | 28 | 15.0 |
| Mason-Dixon | 0 to 300 | |
| Susquehanna-Lehigh | Variable (diversion) | up to 90 |
| Big & Little Elk Creeks | 15 | 8.3 |
| Desalting | | |

## Allocation Schemes

Six possible allocation schemes, all of which would technically satisfy the "Objectives of Water Resource Development," follow. It is recognized that these are only a few of the many possible alternatives that could be implemented. Further, since this is a single-purpose study, considering only the supply aspects of water resources development, more desirable alternatives may exist, since possibly adverse environmental impacts, as well as implications associated with such competing uses as recreation, power, and flood control, may alter the situation.

## SCHEME I

| Service Region | Projects |
| --- | --- |
| Philadelphia City and Northwest | Tocks Island<br>Beltzville |
| Eastern | Ground water and/or<br>Delaware River |
| Southwest and West-Central | Marsh Creek<br>Blue Marsh<br>Maiden Creek<br>Susquehanna-Lehigh<br>Diversion |

Approximately 150 mgd would be diverted from the Susquehanna River at Wilkes-Barre to the Lehigh River, of which approximately 80 mgd would be diverted from the Lehigh near Allentown to tributaries of the Schuylkill River. About 60 mgd would be diverted from the Schuylkill to Brandywine Creek or Marsh Creek Reservoir. The amount of water available from the Blue Marsh Project would be dependent upon the amount of consumption on the Reading area.

## SCHEME II

| Service Region | Projects |
| --- | --- |
| Philadelphia City and Northwest | Tocks Island<br>Beltzville |
| Eastern | Ground water |
| Southwest and West-Central | Mason-Dixon<br>Blue Marsh<br>Marsh Creek<br>Evansburg |

The amount of water available from the Blue Marsh project would be dependent upon the amount of consumption in the Reading area.

## SCHEME III

| Service Region | Projects |
|---|---|
| Philadelphia City and Northwest | Tocks Island<br>Beltzville |
| Eastern | Ground water |
| Southwest and West-Central | Maiden Creek<br>F.E. Walters<br>Marsh Creek<br>Blue Marsh (possible) |

Additional features of this scheme would be a 100 mgd diversion from the Lehigh River at Allentown to tributaries of the Schuylkill River, for conveyance to the Southwest and West-Central Service Regions. About 60 mgd would be diverted from the Schuylkill River to Brandywine Creek or Marsh Creek Reservoir. Water for this diversion would come from the Maiden Creek Reservoir.

## SCHEME IV

| Service Region | Projects |
|---|---|
| Philadelphia City, Northwest, Southwest, West-Central | Tocks Island<br>Beltzville |
| Eastern | Ground water |

It has been estimated that Beltzville and Tocks Island Reservoirs could maintain a flow of 3,965 cfs at Trenton. Since only 3,000 cfs is needed to prevent salt intrusion at Torresdale, the remaining 965 cfs (620 mgd) might supply nearly the entire UMA. However, the request of the State of New Jersey for an additional 300 mgd export would reduce this to 320 mgd, if and when granted by the DRBC.

A major feature of this scheme might be a large intake and pumping facility near the city of Philadelphia, with transmission mains radiating to the north, northwest, and west.

## SCHEME V

| Service Region | Projects |
|---|---|
| Philadelphia and Northwest | Tocks Island<br>Beltzville |
| Eastern | Ground water and/or Delaware River |
| Southwest | Marsh Creek<br>Buck and Doe Run<br>GTS |
| West Central | Blue Marsh<br>Maiden Creek |

The amount of water available from the Blue Marsh Project would be dependent upon the amount of consumption in the Reading area.

## SCHEME VI

| Service Region | Projects |
|---|---|
| Philadelphia City and Northwest | Prompton Modification<br>Hackettstown<br>F. E. Walters<br>Beltzville<br>Aquashicola<br>Trexler<br>Nockamixon<br>Susquehanna-Lehigh Diversion |
| Eastern | Ground water |
| Southwest and West-Central | Marsh Creek<br>Blue Marsh<br>Maiden Creek<br>Buck and Doe Run<br>GTS<br>Icedale |

All of the possible storage above Trenton except Tocks Island would be developed, according to this scheme. Assuming that the Susquehanna-Lehigh Diversion would be the last project completed, it would be used to provide all of the water that the other 5 schemes obtained from Tocks Island. The available water supply from the first seven projects would be short of meeting the Northwest Service Region's stream-flow requirements by the year 1980. Thus, the Susquehanna-Lehigh Diversion would also be needed.

The average flow at Plymouth, Pennsylvania, on the Susquehanna River indicates that 350 mgd could be obtained in such a diversion on an annual basis; however, it might be found that high-water skimming would be required. The capital costs for initial facilities including intakes, pumping plants, and tunnels, for example, to provide 700 mgd over a period of 6 months, would be $90 million.

However, this does not consider the possibility or necessity of either modifying further the Frances E. Walters project for pumping and storage, or an additional storage reservoir. This scheme would require further analysis of engineering feasibility and environmental impacts, particularly on Chesapeake Bay.

## CONCLUSIONS

Public water demands in the Philadelphia-Trention-Wilmington UMA are expected to increase from 658 mgd in the mid-1960's, to 1,000 mgd in 1980, and to 1,990 mgd by the year 2020. The consumptive use of fresh water throughout the UMA by 2020 is expected to aggregate 515 mgd; nuclear power plants are projected to use 480 mgd; and fresh-water diversions at or just above Trenton are expected to reach 435 mgd. As much as 1,430 mgd, therefore, may be lost from the basin, and deficits in treatment plant capacity of at least 734 mgd by 2020 will probably occur.

Ground water development of 172 mgd in the Eastern Service Region will be required, and at least 911 mgd of surface water for stream-flow augmentation, not including 480 mgd for possible nuclear power plant cooling.

The projects enumerated in this study should be evaluated by a full systems analysis to determine the most effective time of construction and allocation of available water, to prevent projected deficits from occurring. Control of development should be coordinated with the programs of the Delaware River Basin Commission, and should be accompanied by active State and local participation.

# CHAPTER 22. ATLANTIC CITY

The Atlantic City Urban Metropolitan Area is located on the coast of southern New Jersey, 60 miles southeast of Philadelphia and Camden. It extends 11 miles along the coast, and from 5 to 10 miles to the west, as far as the Garden State Parkway. Atlantic City is divided among a series of islands, and is the social, economic and political center of the UMA.

The UMA that is expected to evolve by the year 2020 will encompass approximately 115 square miles, and the components anticipated to be partially or totally located within it include:

| | |
|---|---|
| Absecon city | Margate city |
| Atlantic city | Northfield city |
| Brigantine city | Pleasantville city |
| Egg Harbor township | Somers Point city |
| Linwood city | Ventnor city |
| Longport borough | |

The area is delineated on Figure 72.

Both the UMA and Atlantic County are a part of the Coastal Plain physiographic province. The county is a low-lying plain that slopes gently, at about five feet per mile, toward the Atlantic Ocean. Elevations range from sea level on the coast to 152 feet in the west; within the UMA, altitudes are generally less than 50 feet.

The climate of the area is mild and humid, because of the influence of the Atlantic Ocean and the Gulf Stream. The mean temperature is approximately 54°F, while monthly averages range from 36°F in February to 70°F in July. Average precipitation is 44 inches, with an average runoff of about 20 inches. The lengthy summer season and the pleasing climate of the UMA are the principal reasons for its development as a popular vacation area.

Access to other urban areas is provided by a complete system of highway, rail and air transportation. The Garden State Parkway joins the Atlantic City region with Newark and the New York Thruway to the north, and with Cape May to the south. Connections with the Philadelphia-Camden area are made via the Atlantic City Expressway and the Pennsylvania-Reading Railroad Seashore Lines.

Anderson—Nichols & Co., Inc.


ATLANTIC CITY UMA
FIGURE 72

Route 40 is the westerly link to Vineland, and to Wilmington, Delaware. Finally, Bader Field and the Atlantic City Airport are serviced by Allegheny Airlines for transportation to other major airports.

Atlantic City has been developed almost exclusively as a seashore resort. Much of the area's employment force is occupied in the trade and personal services industries, specializing in resort and recreational functions. Other industries within the UMA include apparel and textiles; food; and stone, clay, and glass products.

## POPULATION

The UMA's primary centers of population include Atlantic City and the contiguous cities of Brigantine and Ventnor. Their combined population in the mid-1960's was approximately 65,000, or about fifty percent of the entire population of the UMA.

The growth rate of most of the individual communities has been substantial; but the decline in population of Atlantic City, Pleasantville city, and Egg Harbor township has limited the overall population increase of the UMA to 2.5 percent in the 1960-70 decade. The desire to relocate from the older urban areas to the surrounding "bedroom" suburban communities accounts for the shift in population.

Projections indicate that the UMA will grow considerably within the next 50 years, increasing its population by more than 75 percent. Population density figures are shown in Table 91.

TABLE 91

POPULATION DATA

ATLANTIC CITY UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 122.3 | 129.5 | 135.5 | 185.5 | 229.0 |
| Population per square mile | 1065 | 1125 | 1180 | 1615 | 1990 |

TABLE 92

WATER USAGE

ATLANTIC CITY UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 20.1 | 25.9 | 39.6 | 55.6 |
| Publicly-supplied industrial | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL M & I | 20.1 | 25.9 | 39.6 | 55.6 |
| Publicly-supplied industrial | 0.0 | 0.0 | 0.0 | 0.0 |
| Self-supplied industrial | 2.0 | 2.5 | 3.0 | 4.0 |
| TOTAL INDUSTRIAL | 2.0 | 2.5 | 3.0 | 4.0 |
| Water Use (gcd) (Based on M & I) | 158.0 | 191.0 | 213.0 | 243.0 |

POPULATION AND M&I WATER USE
ATLANTIC CITY UMA

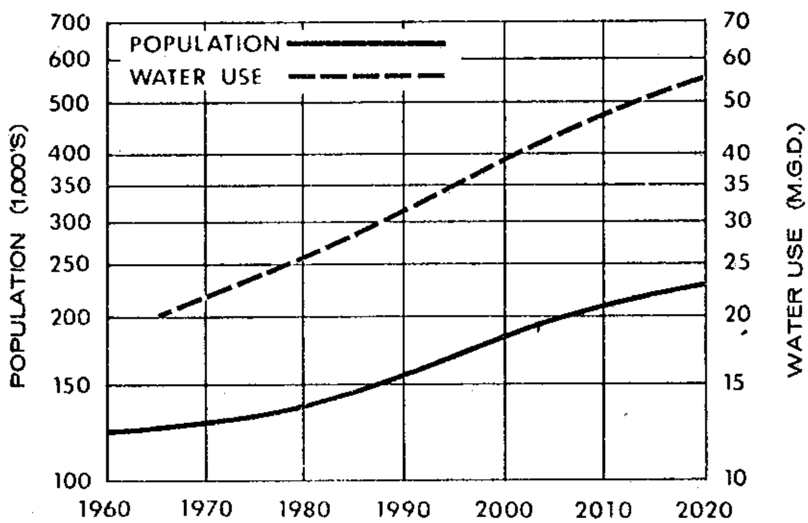



FIGURE 73

## WATER USAGE

Available data indicate that in the mid-1960's, about 127,000 people were served by large and small water supply systems throughout the UMA. The average publicly supplied municipal and industrial demand at that time was about 20 million gallons per day.

No provisions have been made to supply industry with water from public systems in the future, because the Atlantic City UMA is essentially a tourist area. Total industrial consumption in the area is quite small, and little or no water is supplied at present from public systems. Any additional water needed by industry will more than likely be developed privately, from ground water aquifers. Accordingly, the projections for water usage shown in Table 92, reflect only an increase in domestic water. Figure 73 illustrates graphically population projections and M & I water demands for the UMA.

## KNOWN WATER SUPPLIES

### Summary

The UMA has six water supply systems which provide water to almost all of the population.

The Atlantic City Water Department is the largest utility within the UMA, supplying more than 60,000 people with about 13.5 mgd. The water comes from two sources, whose combined safe yield is about 28 mgd: the Atlantic City Reservoir, and thirteen ground water wells. The Department also provides stand-by service to nine hotels, located within the City, which have their own private wells. The Atlantic City utility is connected with the Ventnor City Water Department for emergency water supply. It was once also linked with the Atlantic County Water Company, but the pressure difference between the two systems caused discontinuation of the connection.

The second largest system is the Atlantic County Water Company, a privately owned water utility. It is a regional system, providing water to the communities of Somers Point, Northfield, Linwood, Absecon, Egg Harbor, and Pleasantville. The utility supplies water to 41,000 people from ten wells that have an aggregate safe yield of about 9.0 mgd.

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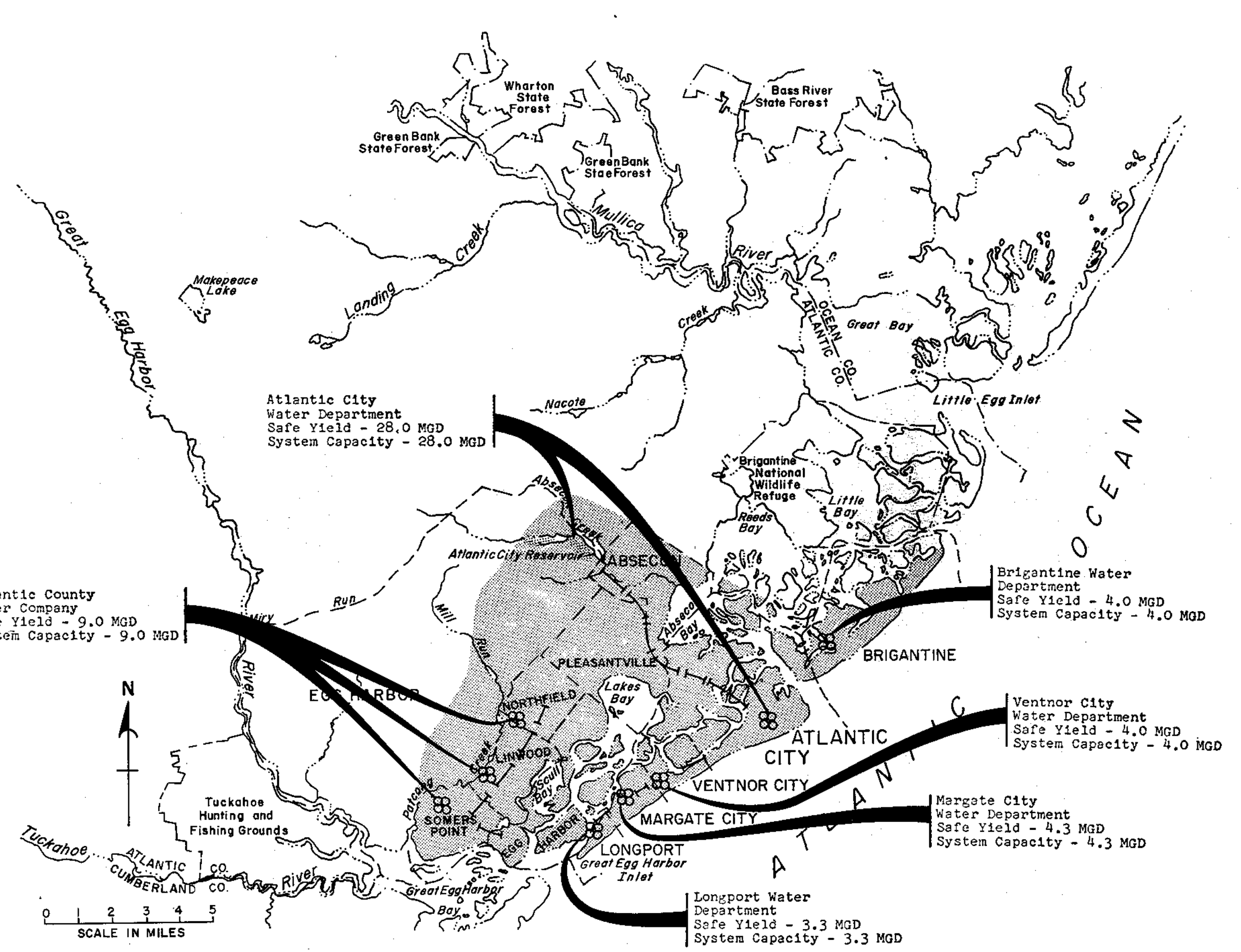



KNOWN WATER SUPPLIES
ATLANTIC CITY UMA
FIGURE 74

The remaining four systems within the UMA are operated by the cities of Brigantine, Longport, Margate, and Ventnor. Each except Brigantine has emergency connections with its neighbors. Water is obtained from ground water sources from either the Kirkwood Formation, or the Cohansey Sand aquifer.

Data pertinent to each of the six systems are in Table 93, and they are depicted graphically in Figure 74.

TABLE 93

KNOWN WATER SUPPLIES

ATLANTIC CITY UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Atlantic City Water Department | 60,000 | 13.50 | Ground Water Wells - 13 | | 19.0 | -- | -- | 19.0 |
| | | | Surface | Atlantic City Reservoir | 9.0 | -- | -- | 9.0 |
| Atlantic County Water Company | 41,000 | 2.40 | Ground Water Wells - 10 | -- | 9.0 | -- | -- | 9.0 |
| Margate City Water Department | 11,000 | 1.70 | Ground Water Wells | -- | 4.3 | -- | -- | 4.3 |
| Ventnor City Water Department | 10,000 | 1.60 | Ground Water Wells | -- | 4.0 | -- | -- | 4.0 |
| Brigantine Water Department | 4,500 | 0.60 | Ground Water Wells | -- | 4.0 | -- | -- | 4.0 |
| Longport Water Department | 600 | 0.30 | Ground Water Wells | -- | 3.3 | -- | -- | 3.3 |

## Future Adequacy

The combined capacity of the six major systems amounts to 52.6 mgd, and most of the water is available from already developed ground water aquifers. Even though a shortage of 3.0 mgd is indicated for the year 2020 on Table 94, no deficit should ever materialize, because additional well fields may be developed.

TABLE 94

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

ATLANTIC CITY UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 20.1 | 25.9 | 39.6 | 55.6 |
| Present Capability (mgd) | 52.6 | 52.6 | 52.6 | 52.6 |
| Deficit (mgd) | -- | -- | -- | 3.0 |

## DESIRABILITY FOR REGIONALIZATION

Regionalization and its advantages have been considered in the Atlantic City UMA and, to some extent, have been implemented. The privately-owned Atlantic County Water Company supplies six communities, which cover more than 30 square miles, on a regional basis. The Company has recognized that suburbanization and water requirements will continue to increase; accordingly, it is arranging to become a totally regional system, for better service to its customers. If the engineering and hydraulic differences between the Atlantic City Water Department and the Atlantic County Water Company can be reconciled, emergency connection could be reestablished, further enhancing a regional system.

The foundation for a totally regional system throughout the UMA already exists, not only because of the regional aspect of the Atlantic County Water Company, but also because of the emergency connections which have been made among all but one of the smaller water supply utilities.

## DEVELOPMENT ALTERNATIVES

The current supply and availability of ground water will more than suffice to meet the projected demands of the UMA. The only conceivable difficulty might be in completion of additional well field development. The available resources, however, must be protected from surface contamination, and from overpumping that would cause salt-water intrusion.

Should the ground water resources become unusable, possible alternatives would include importation of water from the Delaware River, desalting of brackish well water, or desalting of ocean water. However, the required source of power for the ocean desalting process would probably come from nuclear generators, and the New Jersey Legislature is considering the enactment of a law that would prohibit their construction.

The Atlantic County Planning Board has pointed out the desirability of establishing a county or bi-county water authority (with Cape May) to realize the potential of regional water supply, in much the same manner as has been accomplished by the Atlantic County Sewerage Authority.

## CONCLUSIONS

The present water supply situation is quite favorable in the Atlantic City UMA and should continue to be so throughout the time frame of this study. Developed capacity almost equals the 2020 demand; however, the major problem facing the UMA is the possible widespread contamination of its valuable ground water resource. The State and the water supply systems are aware of the problem. Although the utilities may continue their present operational procedures, they should also recall the advantages of regionalization: better control of resources; mass interconnections; and monitoring of development and contamination.

# CHAPTER 23. VINELAND

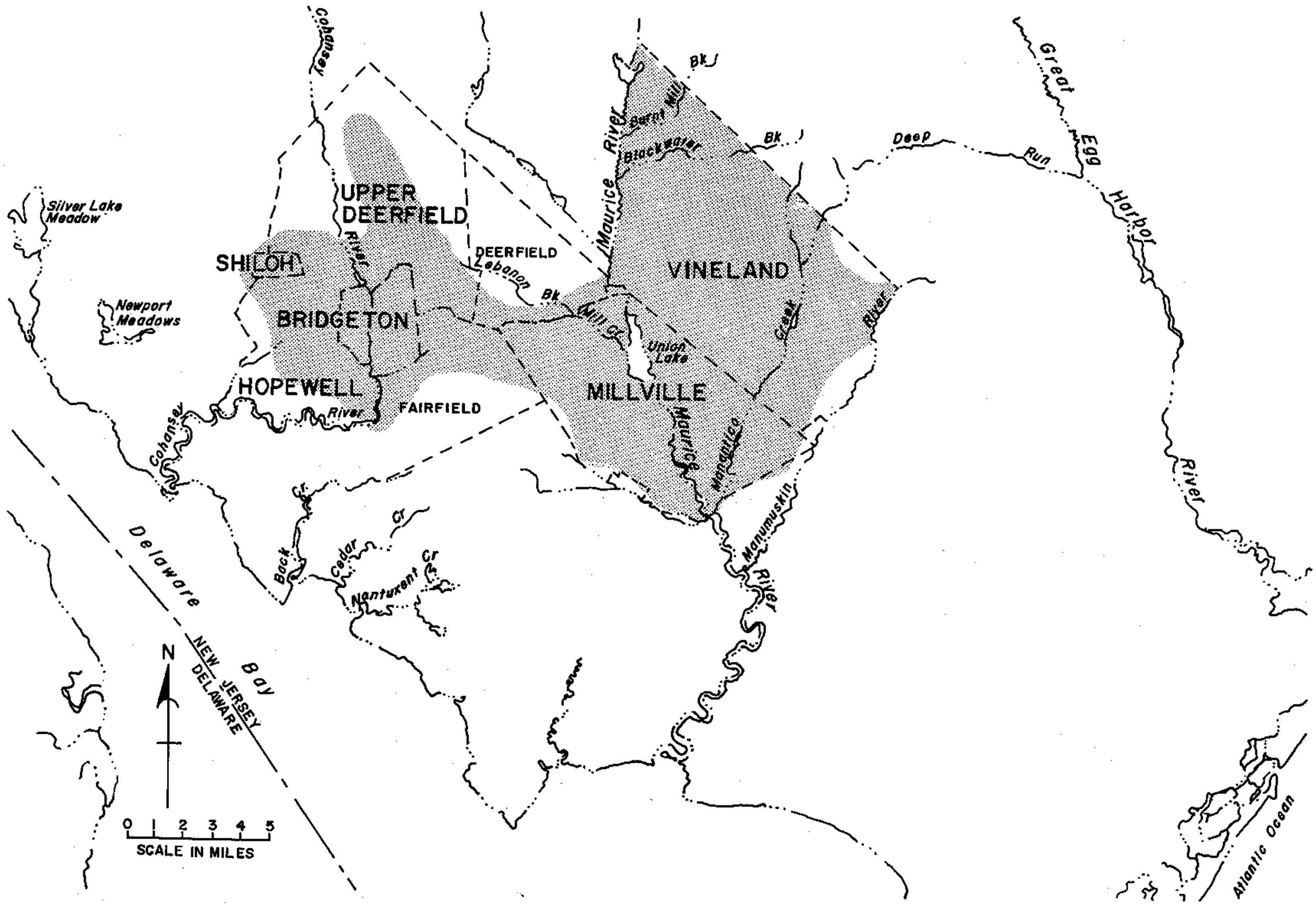
The Vineland Urban Metropolitan Area is situated 10 to 15 miles inland from the Delaware Bay in the northern part of Cumberland County, New Jersey. The UMA occupies quite an enviable location in its proximity to three surrounding metropolitan areas: Philadelphia-Camden, 40 miles to the north; Wilmington, Delaware, 30 miles to the northwest; and Atlantic City, 30 miles to the east.

The UMA that is expected to evolve by the year 2020 will include the cities of Vineland, Millville, and Bridgeton, known as the tri-cities area, and portions of the contiguous townships of Hopewell, Upper Deerfield and Deerfield. The total land area covers approximately 105 square miles, or 37 percent of Cumberland County. The UMA is depicted on Figure 75.

The Vineland UMA lies in the physiographic region of the Atlantic Coastal Plain, within the drainage area of the Delaware Bay. The Cohansey River, Maurice River, and numerous small creeks in the area flow directly into the Delaware Bay. The whole county is generally quite flat; elevations within portions of the UMA usually range from 40 to 100 feet above sea level.

The Delaware Bay, the Gulf Stream, and the Atlantic Ocean provide a stabilizing effect on the climate of the region. The Vineland UMA, therefore, experiences longer summers and milder winters than inland areas, although the high humidity accompanying the mild climate sometimes accentuates the effects of extreme temperatures. The average temperature is about 53°F, with average January and July temperatures of 30°F and 76°F, respectively. Snowfall is light, and comprises a very small portion of the average precipitation of 44 inches. Annual runoff is about 20 inches.

Even though the present highway system of the UMA is inadequate, travel within the area is accomplished mostly by private automobile. Regional plans have been proposed for the construction of freeways, highways, and arteries, for improvement of service within the area, and for better connections to Atlantic City, Philadelphia, and Wilmington. At present, New Jersey Route 49 joins Bridgeton and Milville with Wilmington, to the northeast, and with the Garden State Parkway to the southeast. Routes 47 and 55 provide north-south travel to Philadelphia and Cape May.




VINELAND UMA
FIGURE 75

The Pennsylvania-Reading Seashore lines and the Central Railroad of New Jersey provide some rail transportation, but major air service requires a 45-mile drive north to the Philadelphia International Airport. Small air fields near the tri-cities area furnish localized freight and charter service.

Urban development is clustered around the three major cities forming the core of the UMA. Glassmaking and food processing are the dominant industries, because of the proximity of high quality silica sand, and locally grown fruits and vegetables. Clothes and textile manufacturing also occupy some of the employment force.

Continuous growth in manufacturing is accompanied by a decline in agricultural production, however, and so the economy of the region is in a transitional state. Rapidly rising land values and the demand for suburban housing and attendant functions are inducing farmers to sell prime agricultural land. In Cumberland County, which encompasses and surrounds the UMA, land use between 1959 and 1964 showed a decrease in farm acreage of about 21 percent. A large portion of the land being taken is within the boundaries of and adjacent to the UMA.

## POPULATION

During the last decade, the population of the UMA increased by almost 14 percent. Vineland, the largest city, had the greatest percentage increase, approximately 26 percent. Projections indicate that by the year 2020, the area will increase in population by more than 85 percent over the 1970 level. Population and density figures for the UMA are shown in Table 95.

TABLE 95

POPULATION DATA

VINELAND UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 87.9 | 100.4 | 120.0 | 152.0 | 186.0 |
| Population per square mile | 835 | 955 | 1145 | 1450 | 1770 |

TABLE 96

WATER USAGE

VINELAND UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 9.0 | 15.3 | 24.3 | 36.5 |
| Publicly-supplied industrial | 2.5 | 3.1 | 3.8 | 4.8 |
| TOTAL M & I | 11.5 | 18.4 | 28.1 | 41.3 |
| Publicly-supplied industrial | 2.5 | 3.1 | 3.8 | 4.8 |
| Self-supplied industrial | 25.0 | 28.0 | 34.3 | 43.0 |
| TOTAL INDUSTRIAL | 27.5 | 31.1 | 38.1 | 47.8 |
| Water Use (gcd) (Based on M & I) | 184.0 | 153.0 | 185.0 | 222.0 |

POPULATION AND M&I WATER USE

VINLAND UMA

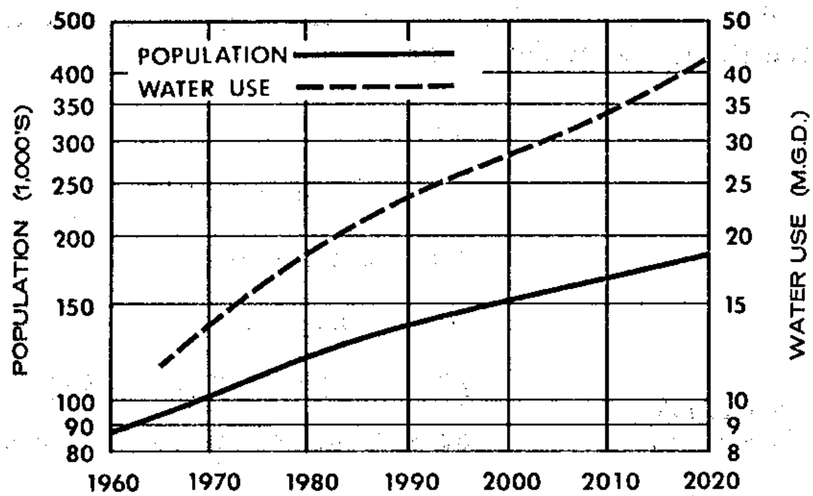



FIGURE 76

## WATER USAGE

Available data indicate that about 62,500 people were served by five water systems throughout the UMA during the mid-1960's, and the total industrial demand for water at that time was estimated to be 27.5 mgd. Of this amount, less than 10 percent was publicly supplied. The industrial demand is expected to amount to 47.8 mgd by the year 2020; however, because of the abundance of ground water, it was assumed that the percent of industrial water publicly supplied will remain approximately constant, and that most of the increase in industrial demand will be met from private wells.

The projections for water usage for the UMA are shown in Table 96, while Figure 76 depicts graphically the trends in population and water use.

## KNOWN WATER SUPPLIES

### Summary

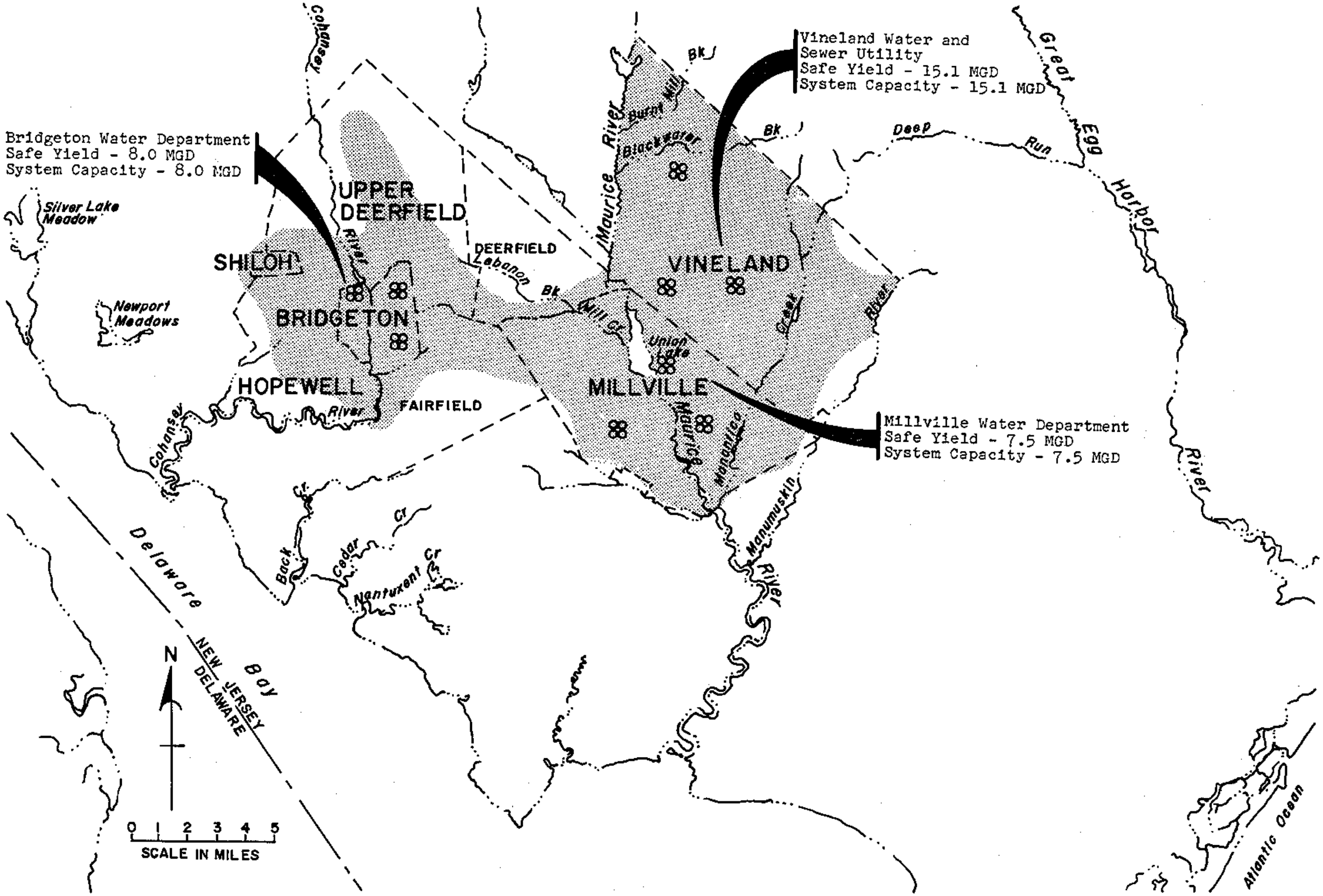
There are five water utilities operating within the UMA. Three of these, the Bridgeton Water Department, the Millville Water Department, and the Vineland Water and Sewer Utility, are publicly owned and can be considered major systems.

The Bridgeton Water Department obtains its water from 12 wells, located within the city limits, having a combined safe yield of approximately 8.0 mgd. In 1965, the system's average output was about 3.7 mgd, or 46 percent of the safe yield. By 1968, output had increased to 4.1 mgd.

The Millville Water Department obtains its water from 11 wells, within the city limits, that have a combined safe yield of approximately 7.5 mgd. In 1965, the utility's average output was about 3.6 mgd, or 48 percent of the safe yield. Use increased to about 3.8 mgd in 1968.

The Vineland Water and Sewer Utility obtains its water from 10 wells, distributed throughout the city, that have a combined safe yield of approximately 15.1 mgd. In 1965, the utility operated at about 27 percent capacity, pumping an average of 4.0 mgd, but this increased to 5.3 mgd by 1968.

Figure 77 shows the major existing water supply systems, and Table 97 contains data essential to each.

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KNOWN WATER SUPPLIES
VINELAND UMA
FIGURE 77

TABLE 97

KNOWN WATER SUPPLIES

VINELAND UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Bridgeton Water Department | 21,500 | 3.66 | Ground Water Wells - 12 | -- | 8.0 | -- | -- | 8.0 |
| Millville Water Department | 17,000 | 3.63 | Ground Water Wells - 11 | -- | 7.5 | -- | -- | 7.5 |
| Vineland Water and Sewer Utility | 20,000 | 4.03 | Ground Water Wells - 10 | -- | 15.1 | -- | -- | 15.1 |

## Future Adequacy

The combined safe yield of the three major water utilities is 30.6 mgd from ground water sources, and as shown in Table 98, the water supply situation is quite favorable.

The only foreseeable problem in the future is the possibility that the excellent aquifer supplying water to the area could be spoiled, either by poor resource management or man-made contamination. Effective management will insure the supply and quality of the water resources throughout the time frame of this study. The projected 2020 deficit of 10.7 mgd can be met by developing additional wells in the UMA.

TABLE 98

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

VINELAND UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 11.5 | 18.4 | 28.1 | 41.3 |
| Present Capability (mgd) | 30.6 | 30.6 | 30.6 | 30.6 |
| Deficit (mgd) | -- | -- | -- | 10.7 |

## DESIRABILITY FOR REGIONALIZATION

The desirability for regionalization in the UMA has been recognized, and already implemented to some degree.

Ground water is perhaps the most important resource available throughout the area. UMA residents are aware that indiscriminate use or contamination of resources, even at one local site, could jeopardize the entire aquifer for use as a water supply. Consequently, the State of New Jersey has enacted legislation to protect surface and ground water resources. Cumberland County, which contains the Vineland UMA, has been delineated as a protected area under the legislation. If any person, corporation, or public agency desires to obtain water from subsurface or percolating sources in excess of 100,000 gallons a day for any purpose, permission first must be obtained from the Division of Water Policy and Supply. The Division has the responsibility of determining what type of permit is required, so that diversion of subsurface or percolating waters will not threaten or impair the water's natural replenishment.

Furthermore, the Cumberland County Planning Board has recommended that a network of observation wells be established throughout the County to monitor the ground water quality and any hydraulic pressure changes continuously. The wells could also provide additional knowledge of the County's geologic composition.

Since the state law has provided the framework for controlling the UMA aquifer, a regional water board might be established to protect the aquifer and oversee its development.

## DEVELOPMENT ALTERNATIVES

Because of the UMA's physiographic location, its expected growth pattern, and its abundance of ground water, it is unlikely that a course of action other than the utilization of ground water to meet the demands will be followed.

The only problems facing the UMA's water supply are institutional ones: water management must be practiced by all of the people. This, of course, necessitates cooperation and implementation of programs to protect the ground water supply from overuse or contamination. Consideration should be given, if the need ever arises, to the recharge of aquifers from stormwater or wastewater reuse or from Delaware River water importation. (See also Chapter 22).

Regionalization can be achieved by each of the present systems cooperating together and determining how the growing urban and industrial segment should best be served; physical interconnection does not seem necessary for the UMA, at present.

## CONCLUSIONS

The projected deficit is not critical because southern New Jersey contains beneath its surface one of the most abundant ground water reserves in the nation. Although the supply is not inexhaustable, with proper management the ground water source can more than satisfy the water needs of the UMA. Proper management is the key to the water supply of the area. If procedures are implemented to insure that the quality of the aquifer is not endangered by man or nature, the water supply situation will remain excellent throughout the time frame of this study.

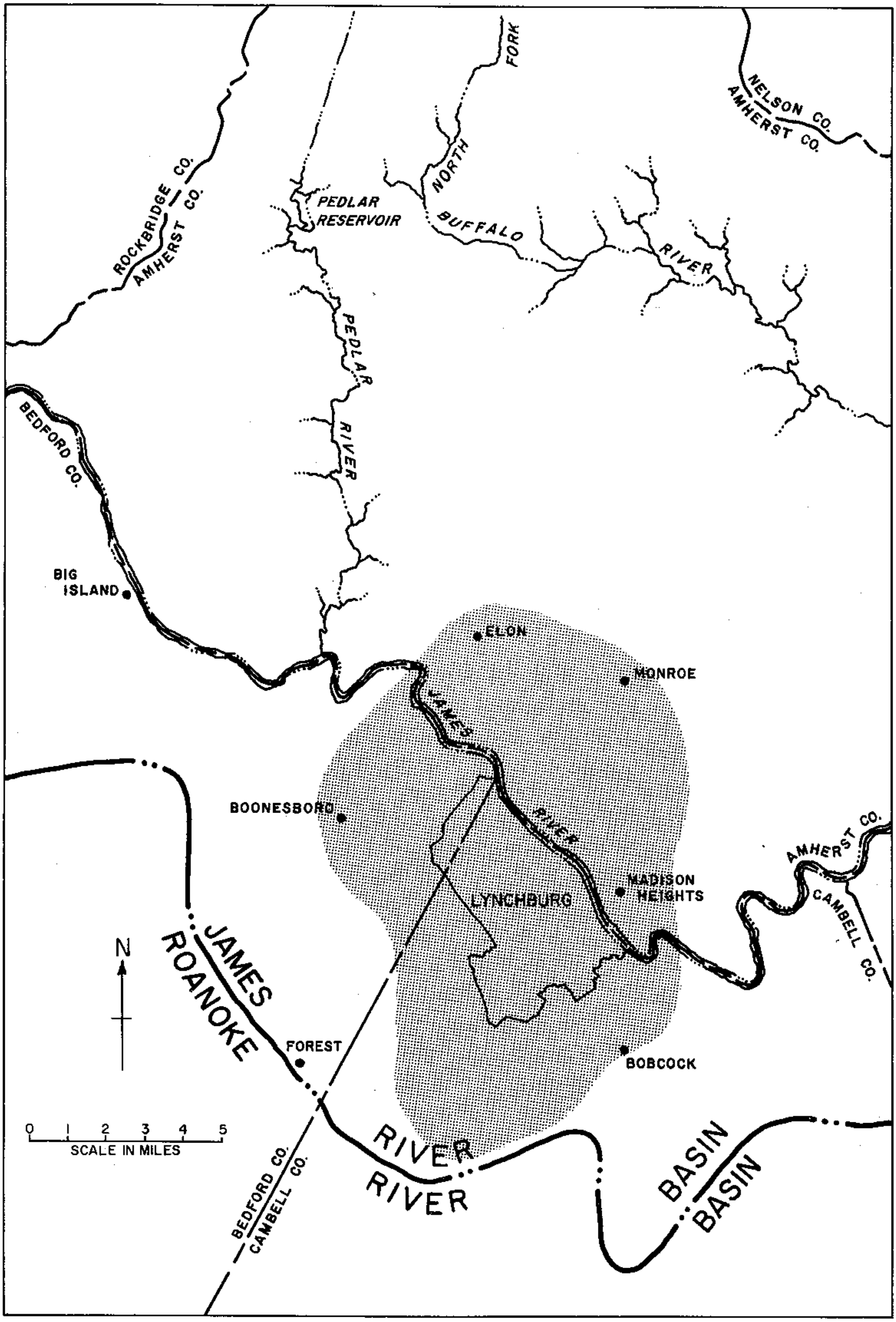
# CHAPTER 24. LYNCHBURG

The Lynchburg Urban Metropolitan Area is located in the Piedmont Province of central Virginia, and contains the city of Lynchburg and urban areas within portions of the surrounding counties: Brookville District (Campbell County), Forest District (Bedford County), and Elon District (Amherst County). It is these areas that essentially comprise the economic and social core of the Lynchburg Standard Metropolitan Statistical Area. The UMA expected to evolve by the year 2020 encompasses approximately 100 square miles, and is shown on Figure 78. While early development in the area centered around industrial sites on the James River, urbanization has recently spread along ridges to the south, southwest, and west of the center of Lynchburg.

Lynchburg's topography is characterized by hills and valleys, and the James River, which passes through the UMA in a northwest to southeast direction, just above the city. Elevations vary from approximately 500 feet above sea level at Lynchburg to over 1,000 feet in Campbell County, the southeastern portion of the UMA.

Climate throughout the James River Basin is classified as temperate. Mean temperature at Lynchburg for 16 years of record is 56.8$^{\circ}$F, while extreme monthly averages during the same time were 76.1$^{\circ}$F in July and 38.1$^{\circ}$F in January. Because of its location in a basin surrounded by the Blue Ridge Mountains, Lynchburg experiences moderate winters. Relative humidity averages 70.5 percent, with prevailing winds from the southwest; precipitation amounts to an average of 39.6 inches, and annual runoff is about 13 inches.

Lynchburg is well served by U. S. Highways 501, 460, and 29, which connect the city to other metropolitan areas of Virginia, and by State routes that pass through the city in all directions. Rail service for both passenger and freight operations connecting Lynchburg to all principal areas of the nation is provided by the Southern, Chesapeake and Ohio, and Norfolk and Western Railways. The city-owned Municipal Airport is served by Piedmont Airlines for service to Washington, New York, and Chicago; and by Cardinal Airlines, a locally-based commuter service to other Virginia cities; Washington, and Greensborough, North Carolina.




LYNCHBURG UMA
**FIGURE 78**

In recent years, the area has developed diversified manufacturing interests, primarily in fast-growing, relatively high-wage industries such as metals, machinery, and nuclear power generation equipment. There are also plants that produce shoes, textiles, iron castings, tires, consumer durable goods and paper products, to name a few. Large industrial water users are generally situated in the northern part of the city, although several new industries have located in industrial parks on the outskirts. In essence, the UMA has a sound economic foundation, and the potential for continued growth.

## POPULATION

Population in the Lynchburg UMA has climbed steadily over the past 70 years, from 35,133 to a peak of 86,500 at present, exhibiting a good economic base for industry, and a desirable location for residency. Development in Lynchburg has been aided by its location on the James River, an excellent transportation complex, and an educational program of high quality.

Because Lynchburg itself has nearly reached population saturation, most of the UMA's future growth is anticipated for the adjacent magisterial districts of Amherst, Bedford, and Campbell Counties. Population projections and density data are presented in Table 99 .

TABLE 99

POPULATION DATA

LYNCHBURG UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 82.7 | 86.5 | 90.0 | 103.0 | 115.0 |
| Population per square mile | 825 | 865 | 900 | 1,030 | 1,150 |

## WATER USAGE

Available data indicate that about 63,500 people and several industries received about 10.5 million gallons per day from the city of Lynchburg water supply system during the mid-1960's. Domestic

TABLE 100

WATER USAGE

LYNCHBURG UMA

| | Mid-1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 6.5 | 10.0 | 13.5 | 17.5 |
| Publicly-supplied industrial | 4.0 | 6.0 | 10.0 | 16.0 |
| TOTAL M & I | 10.5 | 16.0 | 23.5 | 33.5 |
| Publicly-supplied industrial | 4.0 | 6.0 | 10.0 | 16.0 |
| Self- supplied industrial | 29.0 | 32.0 | 33.0 | 41.0 |
| TOTAL INDUSTRIAL | 33.0 | 38.0 | 43.0 | 57.0 |
| Water Use (gcd) (Based on M & I) | 165.0 | 178.0 | 228.0 | 291.0 |

POPULATION AND M&I WATER USE
LYNCHBURG UMA

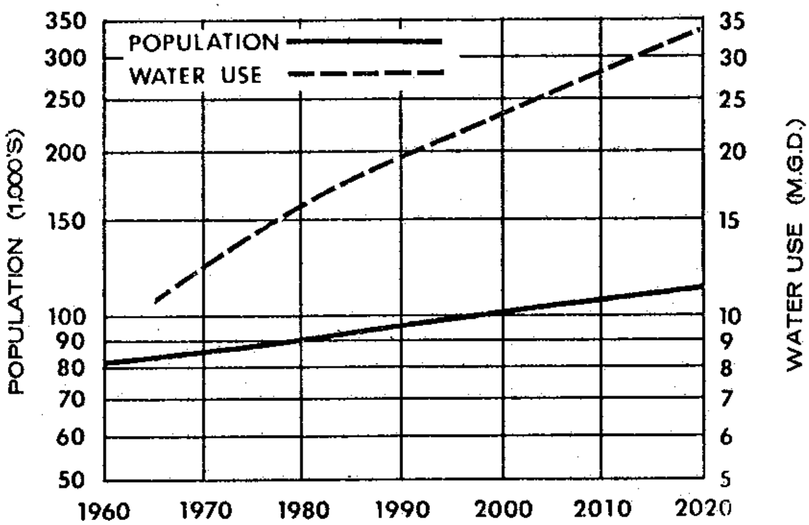



FIGURE 79

usage at that time approximated 6.5 mgd, and is expected to rise to 17.5 mgd by the year 2020. Industrial usage, estimated to be about 33 mgd at present, is expected to increase to 57 mgd. Data pertinent to water usage are presented in Table 100, while the anticipated future trend is depicted graphically on Figure 79 .

## KNOWN WATER SUPPLIES

### Summary

The City of Lynchburg Water Department currently obtains water from two surface sources, Pedlar Reservoir and the James River. Pedlar Reservoir, on the Pedlar River, is located 21 miles northwest of the city, and has an estimated safe yield of 13.0 mgd. Water is transported by gravity to the Lynchburg treatment facilities on College Hill, via a 30-inch wood-stave pipeline having a reported capacity of 18.0 mgd, although 13.0 mgd is probably a more realistic amount.

During the dry summer months, when water demands are high and the yield of the Pedlar Reservoir is low, the city supplements its supply with water from the James River. James River water is obtained through intake and pumping facilities at the base of Seventh Street, and a pipeline to the College Hill treatment plant. The supplementary system has a nominal rating of 8.0 mgd, which equals the pumping capacity. Water obtained from the James is generally of poorer quality than that obtained from Pedlar Reservoir, and operating expenses are somewhat higher, since the water must be pumped against an elevation head of approximately 300 feet.

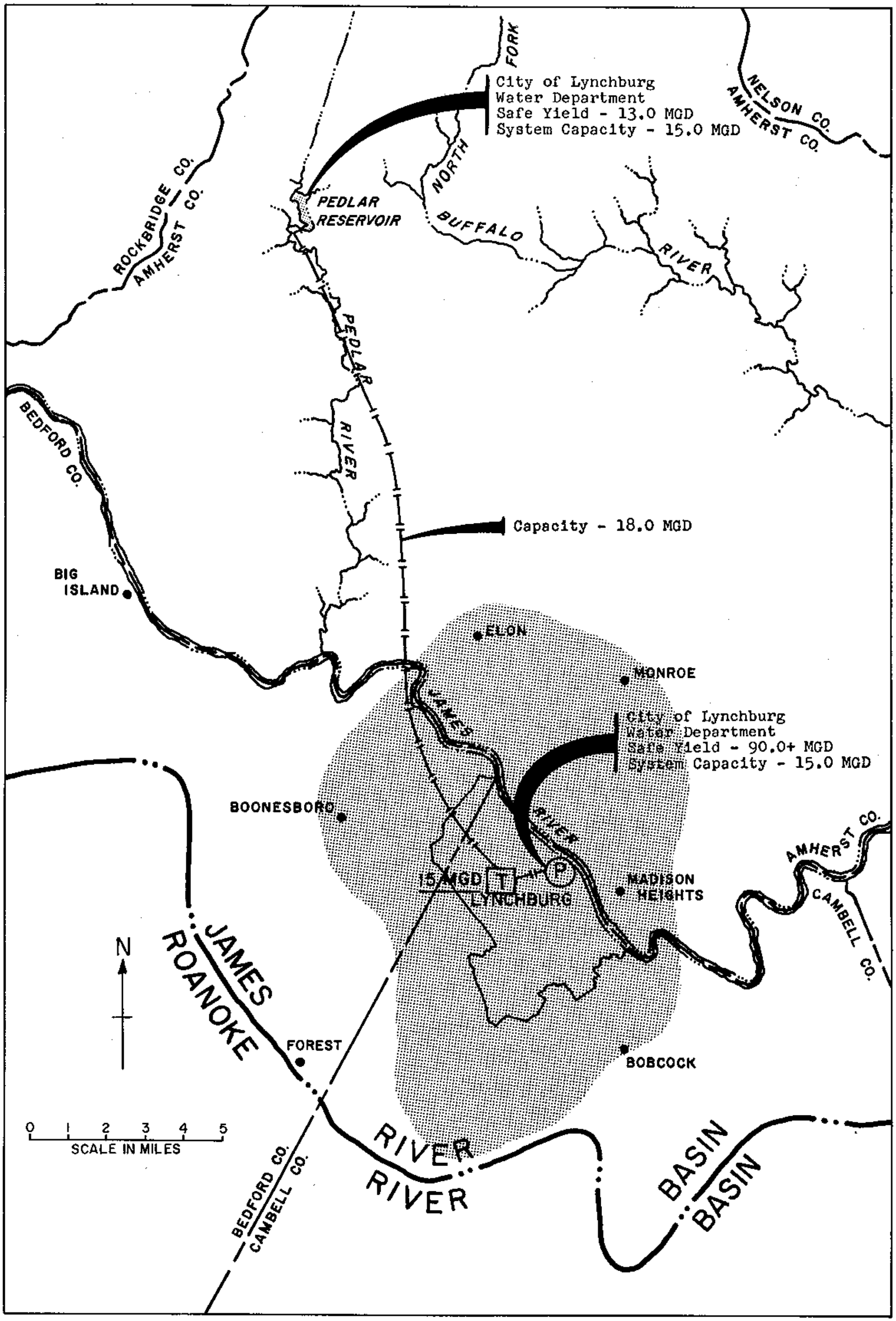
Data pertinent to the Lynchburg water supply system are given in Table 101, while the major facilities are represented on Figure 80.

TABLE 101

KNOWN WATER SUPPLIES

LYNCHBURG UMA

| System | Mid-1960's Pop. Served | Mid-1960's Water Use (mgd) | Type | Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| City of Lynchburg Water Department | 63,000 | 10.5 | Reservoir | Pedlar | 13.0 | 15.0 | 13.0 | 15.0 |
| | | | Emergency | James River | 90.0+ | | 8.0 (pumps) | |




**KNOWN WATER SUPPLIES**
**LYNCHBURG UMA**
**FIGURE 80**

## Future Adequacy

The present capability of the Lynchburg system is rated at 15.0 mgd, the capacity of the city's treatment facilities on College Hill. When compared with projected water demands in Table 102, a deficit in water supply capability becomes apparent for the year 1980.

TABLE 102

ADEQUACY OF PRESENT WATER SUPPLY SYSTEM

LYNCHBURG UMA

| | Mid-1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 10.5 | 16.0 | 23.5 | 33.5 |
| Present Capability (mgd) | 15.0 | 15.0 | 15.0 | 15.0 |
| Deficit (mgd) | -- | 1.0 | 8.5 | 18.5 |

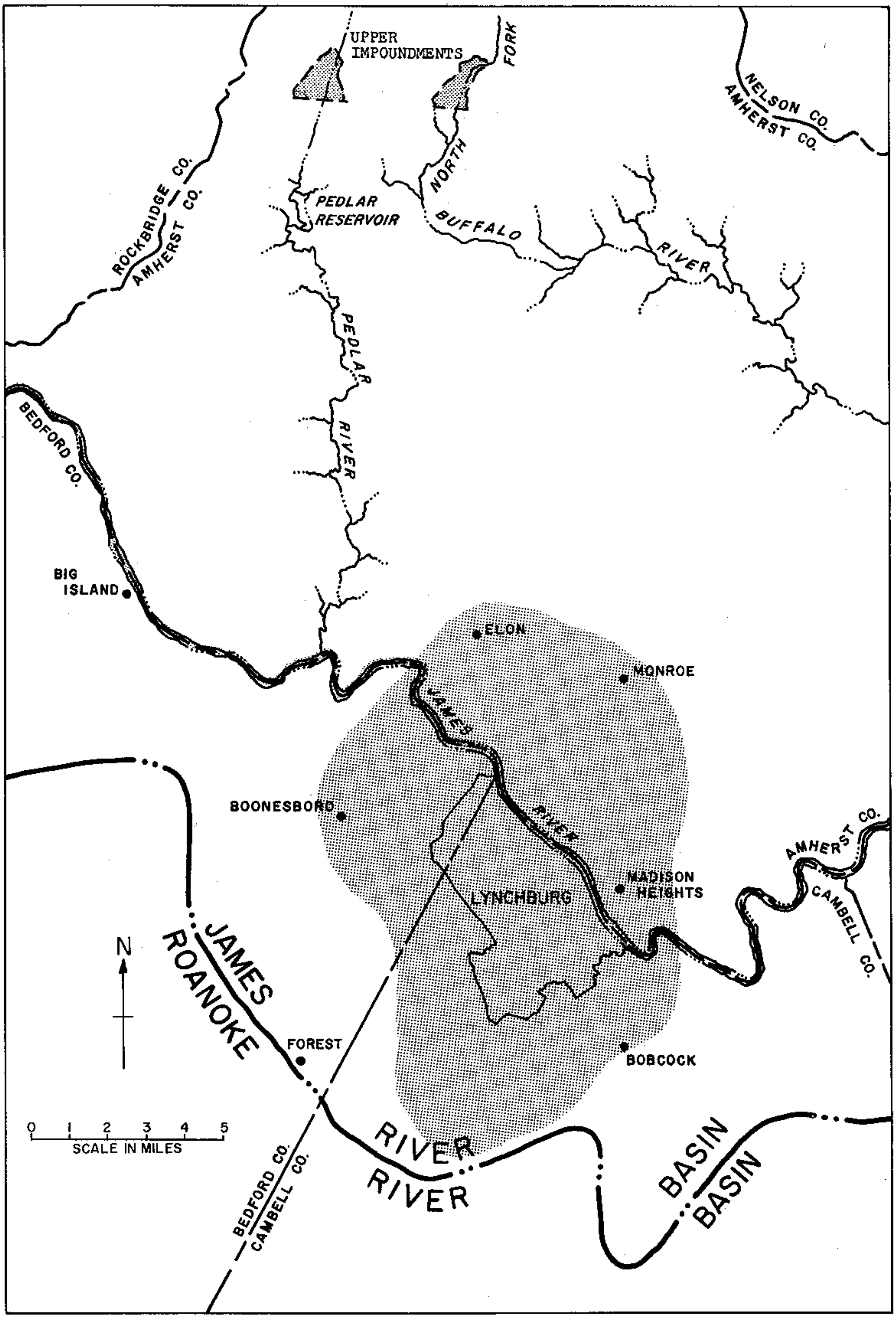
## DESIRABILITY FOR REGIONALIZATION

The Lynchburg UMA is the economic and social hub of the Central Virginia Planning District, which consists of the city of Lynchburg and the four surrounding counties. Several small water utilities are located in the counties, but the desirability of interconnecting any of these utilities with those of Lynchburg is not now apparent.

For all practical purposes, the Lynchburg UMA is already regionalized. The UMA represents the extent of expected urbanization by 2020 in the Lynchburg area, and consequently the extent to which the construction of distribution mains would appear to be economically practical.

## DEVELOPMENT ALTERNATIVES

Two practical alternatives for water supply development exist to meet future needs of the Lynchburg UMA: expanded utilization of the James River, and upland reservoir developments, as shown on Figure 81. Consulting engineers for the city of Lynchburg have indicated that no wells or springs are currently being used for public water supply, and no ground water development should be relied upon in future planning.




**POTENTIAL SOURCES OF SUPPLY
LYNCHBURG UMA**

**FIGURE 81**

## James River

The James River has been used as the emergency source of supply for the city, and as the primary source of water for local industries. As a domestic source, it has been the subject of complaints because of excessive odor and color. Industrial effluent from the vicinity of Big Island, about 12 miles upstream of Lynchburg, has created the problem, which is most noticeable during the summer months when river flow is at a minimum, and water demands are high. The enforcement of existing legislation, such as the 1899 Refuse Act or its successor, however, should help to control industrial pollution.

The need for low-flow augmentation of the James River has already been recognized by the Commonwealth of Virginia and by planners. Two proposed projects, Hipes and Gaithright Reservoirs, in the headwaters of the river, should have a noticeable effect on low-flow at Lynchburg. It has been estimated that the two reservoirs will provide a minimum stream flow of 1,100 cfs (710 mgd), which would be more than twice the normal summer drought (7-day duration, 2-year frequency), and five times the low-flow of record for the James River above Lynchburg. The quantity would be many times the municipal and industrial water requirements for the Lynchburg UMA throughout the study period, and would reportedly alleviate the water quality problem at Lynchburg.

Means of delivering water would be accomplished through a pumping station and treatment facilities, the locations of which require a detailed hydraulic analysis. Though construction costs for such a project would be reasonably low, operating costs would be quite high, because of necessary pumping. Despite the 300-foot head against which James River water must be pumped, however, it is reported by consultants for the city that no other alternative would prove more economical.

## Upland Impoundments

Several good dam sites are available for water supply development on the Pedlar and Buffalo Rivers. A scheme suggested by the consultant for Lynchburg includes two futher impoundments on the Pedlar River, and one on the North Fork of the Buffalo River. The plan would entail a diversion from the proposed North Fork Reservoir, to maintain a full storage in Pedlar Reservoir, and two additional reservoirs upstream on the Pedlar River. A quantity of good quality water would thus be available to satisfy demands in Lynchburg for well over 50 years. However, since the capacity of the existing pipeline from Pedlar Reservoir is about 13 mgd, any further impoundment would dictate additional transmission. The cost of 36-inch cast iron pipe from Pedlar Reservoir to the existing College Hill treatment plant (21 miles), is estimated to be nearly $5 million - a substantial undertaking for a city the size of Lynchburg.

Consideration could also be given to a pipe of smaller diameter, possibly made of plastic, snaked through the existing wood stave pipe, that would operate under high pressure. Cost of a 24-inch pipe (250 psi) would be about $3.5 million, including installation; and its capacity, at 10 feet per second, would be about 21 mgd.

### Cost Analysis

A cost analysis, comparing the alternatives of expanded utilization of the James River with upland impoundments, discloses the following points:

- Construction costs for full development of potential upland impoundments would be on the order of $13 million. The plastic pipe might halve the cost, and would nearly double the present capacity. Costs for James River development would be from $1 to $2 million, depending on the location of pumps and treatment plant.
- Although the operating costs of James River pumps would be high, the consultant for Lynchburg has indicated that such an undertaking would prove more economical than the alternative of upland impoundment, with transmission through the 36-inch pipe.
- Treatment costs of James River water would be about ten percent higher than treatment of upland waters.

## CONCLUSIONS

Expected demographic and industrial growth in the Lynchburg UMA will dictate major development of water supply facilities in the very near future.

Although utilization of the James River as the primary source of supply for Lynchburg appears economically more favorable than the alternatives, the people of the Lynchburg UMA may be willing to pay more for continued availability of the same high quality water to which they are accustomed.

However, when the James River augmentation becomes a reality, the most resourceful and economic solution to satisfying water needs in Lynchburg appears to be a variation of the present system. James River water could then be used year round as a supplementary source of supply, while Pedlar Reservoir continues to be used to its full potential, until such time as the 21-mile transmission main becomes defunct, or is replaced.

# CHAPTER 25. RICHMOND

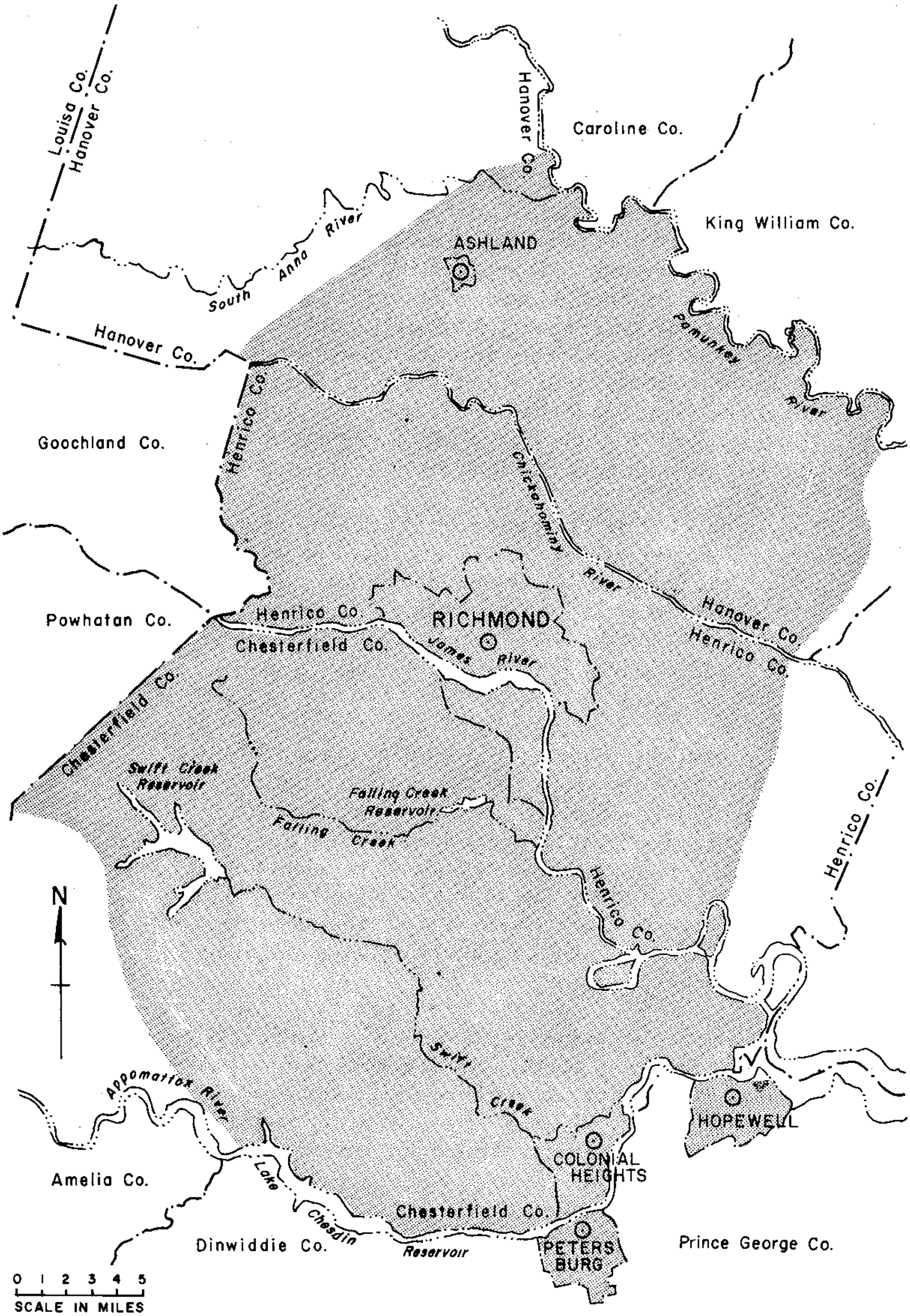
The Richmond Urban Metropolitan Area is located in east-central Virginia and consists of the cities of Richmond, Petersburg, Hopewell, and Colonial Heights, and portions of Hanover, Henrico, and Chesterfield Counties. Richmond, the state capital, lies along the James River, about 100 miles northwest of the river's mouth. Major existing urban development is concentrated in Richmond, with a secondary concentration in the tri-cities of Petersburg, Hopewell, and Colonial Heights. As these four cities rapidly approach population saturation, the counties of Hanover, Henrico, and Chesterfield will continue to accomodate the urban spillover. The anticipated UMA, illustrated on Figure 82, will be irregular in shape, and have a total land area of about 850 square miles.

The Richmond UMA is divided by the Fall Line nearly equally between two physiographic provinces: the Coastal Plain, east of the Fall Line, which is relatively flat; and the Piedmont Plateau, west of the Fall Line, where the land slopes gently downward to the southeast. Elevations in the UMA vary, from slightly above sea level in the east to over 300 feet in the west.

Four major bodies of water flow southeastward within the region: the Pamunkey River, along the northern border of the UMA; the Chickahominy River, natural boundary between Hanover and Henrico Counties; the James River, the Commonwealth's largest river, through the city of Richmond; and the Appomattox River, along the southern boundary of the UMA to Petersburg, then northeastward to a confluence with the James at Hopewell. At the Fall Line, the rivers all change from free-flowing to tidal streams.

The UMA climate is generally classified as temperate, with prevailing winds from the south. The average temperature in the UMA is about 55°F, with extreme monthly averages of 38.7°F in January and 77.9°F in July. Precipitation usually amounts to approximately 44 inches; the annual runoff amounts to about 12 inches.

The network of highways serving the Richmond area is excellent. Interstate Highways 95 and 64 converge at Richmond,



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**RICHMOND UMA**
**FIGURE 82**

and are the major north-south and east-west routes, respectively. The UMA is well serviced also by U.S. and State Routes. The Seaboard Coast Line Railroad, the Fredericksburg and Potomack Railroad, the Chesapeake and Ohio Railway, and the Southern Railway provide rail transportation for the UMA. Scheduled air service links Richmond with major cities on the east coast.

Navigation facilities on the James River, maintained by the Corps of Engineers, have made shipping possible from the industrial centers of Richmond and Hopewell to the coastal port of Hampton Roads.

Economic and industrial development is concentrated at present in the four cities, and along the James River between Richmond and Hopewell. The counties are generally residential, with some agricultural and mining development. Manufacturing is quite diversified; major water using industries are paper, chemical, and canning.

## POPULATION

According to data from the U.S. Bureau of the Census, nearly 50 percent of the 1970 total UMA population was concentrated in the city of Richmond. While the aggregate UMA population is expected to more than double, the city of Richmond is projected to increase by only 33 percent; like most major cities, Richmond is declining in population. Total population for the city had increased steadily until 1950; then the population began to decrease slowly until January 1, 1970. At that time, Richmond annexed a portion of Chesterfield County and raised its population level by more than 23 percent. It is believed that any significant future increase in Richmond's population will result from annexations. Population and population density data are shown in Table 103.

The urban portions of the Richmond UMA have a solid economic base, which should prove attractive to new industries. It is believed, therefore, that the area should experience a population growth somewhat greater than the national average.

Future land development will most probably bring about population saturation of Richmond, Colonial Heights, Hopewell, and Petersburg; intense suburbanization in Chesterfield and Henrico Counties, and particularly along Interstate Routes 64 and 95; many new industrial developments in northern Chesterfield and southern Henrico Counties; and spots of urbanization in Hanover County.

TABLE 103

POPULATION DATA

RICHMOND UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 400.0 | 511.3 | 637.3 | 862.6 | 1,113.9 |
| Population per square mile | 470 | 600 | 750 | 1,015 | 1,310 |

## WATER USAGE

Available data indicate that about 454,500 people and several industries were served by large and small water systems throughout the UMA in the mid 1960's. The average publicly supplied municipal and industrial demand totaled about 76.0 mgd, of which 42.7 mgd were supplied to domestic users, and 33.3 mgd to industry. Water-using industries in the area with their own sources of water supply are estimated to be using a total of approximately 170 mgd for cooling, processing, and other purposes.

Projections of water usage are presented in Table 104, while the expected future trends for both population and water usage are depicted graphically on Figure 83.

## KNOWN WATER SUPPLIES

### Summary

Water service within the Richmond UMA is provided by several public systems. The city of Richmond water supply

TABLE 104

WATER USAGE

RICHMOND UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 42.7 | 62.8 | 96.2 | 137.8 |
| Publicly-supplied industrial | 33.3 | 39.8 | 59.0 | 84.3 |
| TOTAL M & I | 76.0 | 102.6 | 155.2 | 222.1 |
| Publicly-supplied industrial | 33.3 | 39.8 | 59.0 | 84.3 |
| Self-supplied industrial | 170.0 | 186.0 | 260.0 | 339.0 |
| TOTAL INDUSTRIAL | 203.3 | 225.8 | 319.0 | 423.3 |
| Water Use (gcd) (Based on M & I) | 167.0 | 161.0 | 180.0 | 199.0 |

**POPULATION AND M&I WATER USE**

**RICHMOND UMA**

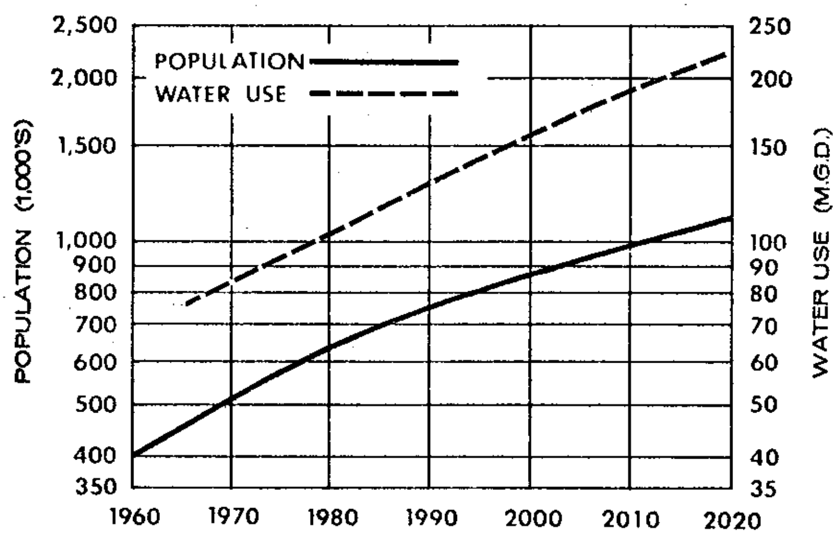



FIGURE 83

system includes intake and treatment facilities on the James River adjacent to downtown Richmond. While the existing treatment plant has a rated capacity of 66 mgd and a peak capacity of 88 mgd, it is estimated that nearly 150 mgd can be obtained from the river for water supply purposes, even during periods of low-flow (based on 7-day, 10-year recurrence interval). Water from the treatment plant is pumped directly into the city's distribution system, which serves Richmond, most of Henrico County, and small portions of both Hanover and Chesterfield Counties.

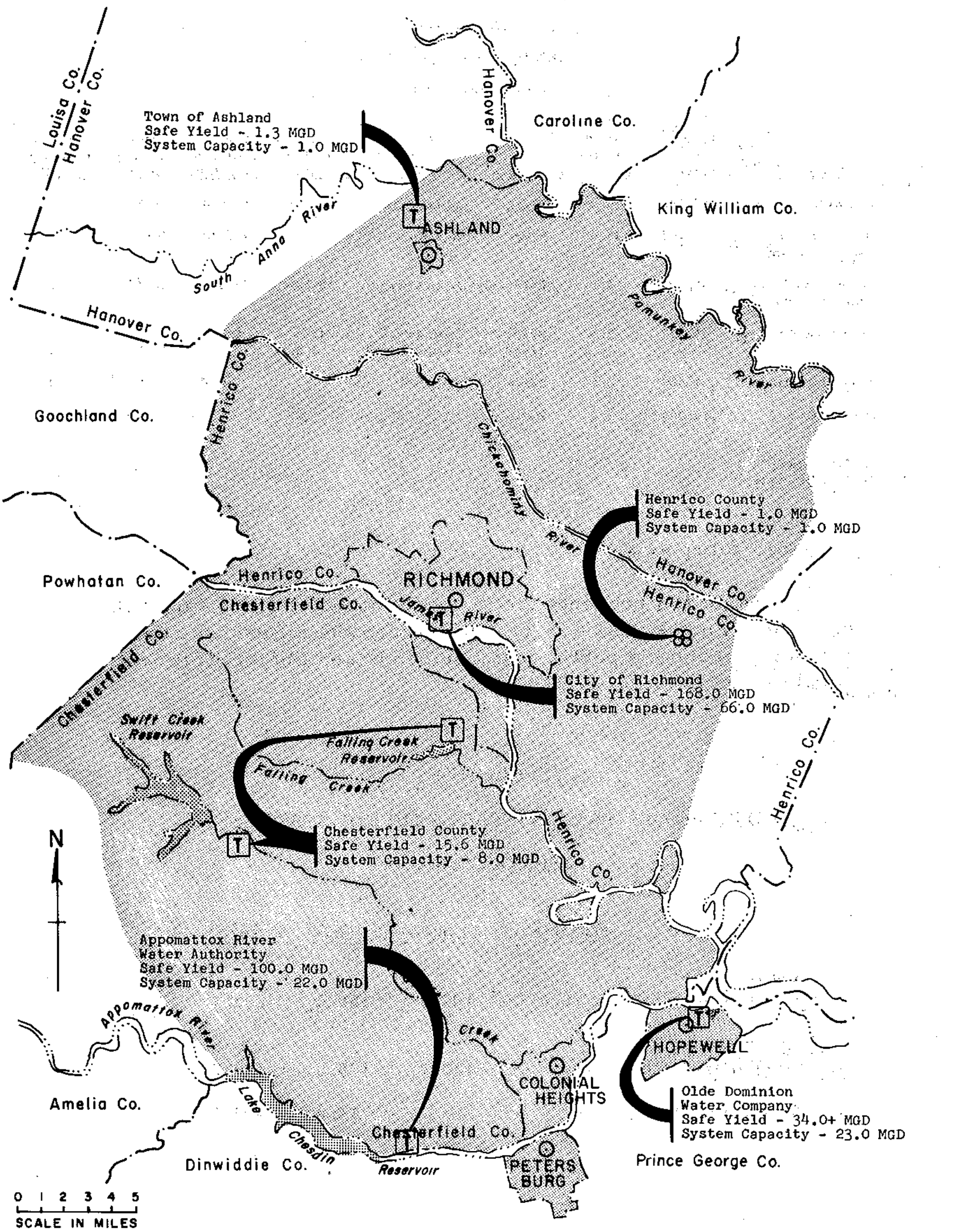
The Appomattox River Water Authority serves the cities of Petersburg and Colonial Heights, and the major part of southern Chesterfield County. Facilities include the recently completed Brasfield Dam, located upstream of Petersburg, and a filtration plant west of Matoaca. The Lake Chesdin Reservoir has a storage capacity of 11.5 billion gallons, and a safe yield of slightly over 100 mgd. The treatment plant has a rated capacity of 22 mgd, and provision was made for future expansion.

The city of Hopewell is served by the Olde Dominion Water Company, a private organization now drawing water from the Appomattox River, near its confluence with the James. Facilities include an intake structure and a treatment plant, with a rated capacity of 23 mgd. During peak-demand periods, the plant has provided up to 35 mgd.

Two reservoirs in Chesterfield County, on Falling Creek and Swift Creek, have a combined safe yield of nearly 16 mgd, though the treatment plants employed for purification possess an aggregate capacity of approximately 8 mgd.

The town of Ashland in Hanover County draws water from the South Anna River. Treatment facilities are rated at 1 mgd, slightly less than the safe yield of the river. Public wells in Henrico County are reported to have a dependable yield of approximately 1 mgd.

A summary of the existing water supply facilities is presented in Table 105; the major facilities are located on Figure 84.




**KNOWN WATER SUPPLIES RICHMOND UMA**
**FIGURE 84**

Anderson-Nichols & Co. Inc.

TABLE 105

KNOWN WATER SUPPLIES

RICHMOND UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| City of Richmond | 305,000 | 36.0 | River | James | 168 1/ | 66.0 | N/A | 66.0 |
| Olde Dominion Water Company | 20,000 | 23.0 | River | Appomattox | 34.0+ | 23.0 | N/A | 23.0 |
| Appomattox River Water Authority | 85,000 2/ | 8.5 | Reservoir | Lake Chesdin | 100.0 | 22.0 | N/A | 22.0 |
| Chesterfield County | 40,000 | 5.0 | Reservoir | Swift Creek | 12.0 | 5.0 | | 5.0 |
| | | | Reservoir | Falling Creek | 3.6 | 3.0 | N/A | 3.0 |
| Town of Ashland | 4,500 | 0.5 | River | So. Anna | 1.3 | 1.0 | N/A | 1.0 |
| Henrico County | 10,000 | 1.0 | Wells | | 1.0 | | N/A | 1.0 |

1/ Allocation
2/ 1970 Estimate

## Future Adequacy

Table 106 presents the projected water deficits for each of the benchmark years. The deficits are the differences between the projected public water demands and the total present capability of existing systems.

TABLE 106

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

RICHMOND UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 76.0 | 102.6 | 155.2 | 222.1 |
| Present Capability (mgd) | 120.0 | 120.0 | 120.0 | 120.0 |
| Deficit (mgd) | -- | -- | 35.2 | 102.1 |

It is important to note that, although a deficit of 102 mgd is indicated for the year 2020, the existing sources of supply have an aggregate safe yield of more than 285 mgd - enough water to supply the UMA well past 2020. The greatest concern to water supply planners in the Richmond UMA is expected to be the design and construction of a distribution system adequate to keep pace with the rapidly developing suburban county areas.

## DESIRABILITY FOR REGIONALIZATION

The most important factor in determining the desirability of regionalization for the Richmond UMA appears to be the capability of the existing systems to meet projected demands. For purposes of analysis, the UMA has been subdivided into four service areas, corresponding to the service areas of the existing water supply systems. Water demands for each area were disaggregated from the entire UMA values, based on present and future population, present water use, and present economic productivity.

The Richmond water-service area includes the city of Richmond, most of Henrico County, and the eastern portion of Hanover County. The area is almost exclusively served by the Richmond system, with public and private wells located in the counties. Water use in the mid 1960's amounted to about 38 mgd, and is expected to increase to about 125 mgd by 2020. Richmond treatment facilities, with a nominal capacity of 66 mgd, will have to be expanded by the year 1990, when demands within the sub-region are expected to approach this capacity. The city, with the James River as its source of supply, need not seek additional sources within the next 50 years, because it has rights to withdraw 168 mgd from the River.

The Ashland water-service area consists of the town of Ashland and the surrounding area of Hanover County. Water use amounted to only about 0.5 mgd in the mid 1960's, although the amount is expected to increase to about 9 mgd in 2020. The only public system in the area is owned by the town of Ashland, and draws water from the South Anna River. The system's treatment plant, with a capacity of 1 mgd, will probably prove inadequate within the next 10 years. Furthermore, without impoundment of the South Anna River, little opportunity to increase direct withdrawal exists, because the River's safe yield is only 1.3 mgd. A reservoir on the river could yield about 12 mgd, but it would probably be more economical for this service area to purchase treated water from the city of Richmond, whenever the present facility becomes inadequate.

The Southern service area consists of Chesterfield County, and the cities of Colonial Heights and Petersburg. Systems serving this region include the Appomattox River Water Authority and those operated by Chesterfield County. The systems have a combined treatment capacity of 30 mgd, from reservoirs with a total safe yield of nearly 116 mgd. They supply about 16 mgd to the public at present, but by 2020, water demands are expected to approach 55 mgd. With farsighted planning on the part of the Appomattox River Water Authority, treatment capacity will be kept ahead of the expected demands. No deficits appear likely within the time frame of this study.

The Hopewell service area consists of the city of Hopewell and Fort Lee. Water use in the area is presently about 23 mgd, primarily industrial, and is expected to increase to 45 mgd by 2020. The area is served by the Olde Dominion Water Company. It is a private company, originally built by the Federal Government to supply industry in the area, and its source is the Appomattox River. While the rated capacity of the company's treatment plant is 23 mgd, up to 36 mgd can be supplied during periods of peak demand. The major future problem confronting the Olde Dominion Water Company is the maintenance of acceptable quality water. The system should be monitored continually to insure that the problem does not materialize. In the event that water of acceptable quality cannot be produced at some time in the future, the area may choose either to join with, or purchase water from the Appomattox River Water Authority. Lake Chesdin, the Authority's reservoir, is expected to be adequate to serve the entire portion of the UMA south of the James River through the year 2020.

In conclusion, it appears that the Richmond UMA might eventually be considered as two water supply regions. The northern region system would obtain water from the James River, and serve that part of the UMA north of the James. The southern region would supply the area to the south of the

James, with Lake Chesdin on the Appomattox River, its chief source of supply. Interconnecting mains between the two regions would probably prove beneficial during periods of peak demand, fire, or breakdown, but the desirability of this would largely depend on hydraulic and economic considerations.

The overall administration of regional water supply planning could come under the auspices of the Richmond Regional Planning Commission - an agency recently established to guide development in Hanover, Henrico, and Chesterfield Counties, and in Richmond. Expansion of the Commission's area of jurisdiction to include Petersburg, Hopewell, and Colonial Heights, would enhance its ability to coordinate development of the UMA as a whole, and consequently to avoid piecemeal or inefficient planning.

## DEVELOPMENT ALTERNATIVES

The Richmond UMA is one of the most water-rich metropolitan areas in the Northeast. The James River and the Appomattox River have the potential to serve the entire UMA. Since physical facilities already exist to deliver water from these two sources, the most desirable course of action for water supply development would appear to be the continued expansion of treatment and distribution facilities.

The northern region should continue to obtain water from the James River, a source reliable in quality and quantity of supply. The River provides an average flow of over 5,000 mgd, with a drainage area above Richmond of 6,757 square miles. Even under the most severe drought conditions, the flow was 225 mgd, the record one-day low-flow. During such periods, however, problems with water quality are evident.

The need for low-flow augmentation in the James River has been considered by both the U.S. Army Corps of Engineers and the State of Virginia, Department of Conservation and Economic Development. Gaithright Reservoir, a Corps project in the James River headwaters on the Jackson River, is currently under construction and will reportedly increase the low flows in the James at Richmond by about 100 mgd. The proposed Hipes and Roundabout Reservoirs, also in the headwaters of the James, could provide additional low flows, thus giving a total of 675 mgd for water supply, if all three reservoirs are constructed.

Completion of administrative proceedings and construction of these projects should be expedited. The city of Richmond would then be able to draw water from the James River sufficient for supply throughout the time frame of this study. Alternatives to the James River would be impoundment of the Pamunkey River, or the purchase of water from the Appomattox River Water Authority.

The southern region should continue to use Lake Chesdin and the reservoirs on Swift and Falling Creeks for public water supply. Enough water is available from these reservoirs to satisfy expected demands well past the year 2020. Expansion of treatment facilities, however, will be necessary.

## CONCLUSIONS

Presently developed sources of water supply should be adequate to serve the Richmond UMA past the year 2020. Expansion of treatment plants and distribution systems will be necessary to accommodate the expected demographic and industrial growth in the area.

Regional planning has been in effect for several years in the UMA. Although one physically integrated water supply system does not appear to be a necessity for the area at this time, such a system might prove to be economically advantageous in the future.

# CHAPTER 26. NEWPORT NEWS

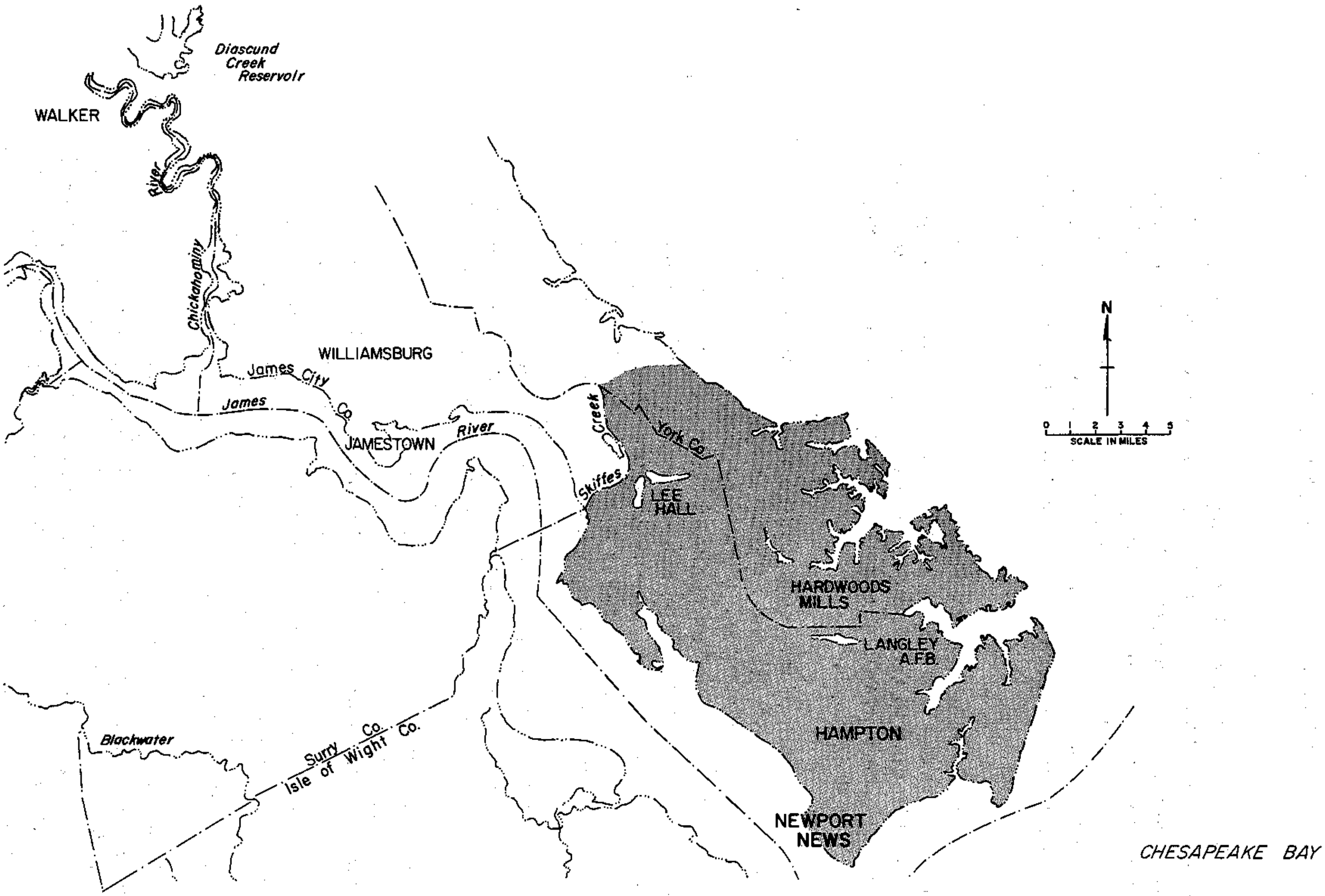
The Newport News Urban Metropolitan Area is located in the southeastern coastal portion of Virginia, approximately 150 miles south of Washington, D.C. As shown in Figure 85, the UMA expected to evolve by the year 2020 will include the cities of Newport News and Hampton, and part of York County. It will encompass approximately 275 square miles of Virginia's middle peninsula, commonly referred to as Northern Hampton Roads.

The UMA is generally flat, with elevations varying between sea level and 50 feet, and is characterized by numerous tributaries leading to the James and York Rivers, and to Chesapeake Bay. The streams are mostly tidal estuaries, draining small basins of low relief.

The climate of the region is noted as temperate. Because of its proximity to the Atlantic Ocean and its latitude of approximately 36°50', the UMA experiences moderate winters. Rainfall averages nearly 50 inches, while snowfall usually amounts to only 10 inches; average runoff amounts to approximately 10 inches. The mean temperature is about 61°F; January and July averages are about 43°F and 80°F, respectively. Winds generally prevail from the southeast.

Because of the importance of the port of Hampton Roads, of which the Newport News UMA is a part, virtually every form of transportation is available. An excellent highway network of both Interstate and U.S. routes provides access to metropolitan areas along the eastern seaboard and inland. Rail service, which is available to all major eastern cities, is provided by the Chesapeake and Ohio Railway; Norfolk, Franklin, and Danville Railway; Norfolk Southern Railway; and the Penn Central Railroad. Air service is available at the Norfolk Regional Airport, approximately 20 miles to the south of Newport News. Other smaller airports and a heliport in Norfolk, are located in the area.

The UMA has many military installations and outstanding port facilities. It is an important shipbuilding center: the Newport News Shipbuilding and Drydock Company operates one of the largest facilities of its kind in the world. Major industries within the UMA presently include food and kindred products; transportation; and printing products.

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**NEWPORT NEWS UMA**

**FIGURE 85**

The Port of Hampton Roads is one of the busiest in the United States, having led the nation in volume of exports in 1969 and placing second in imports that year. It also ranks as one of the nation's leading containerized shipping centers. Historical sites and beaches provide resources for a large tourist industry.

## POPULATION

Population is growing rapidly in the Newport News UMA, as evidenced by an increase of over 30 percent between 1960 and 1970. Population and density figures are presented in Table 107. Projections indicate that the area will increase in population from 261,500 to about 585,000 by the year 2020, or an increase of nearly 125 percent.

TABLE 107

POPULATION DATA

NEWPORT NEWS UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 201.4 | 261.5 | 340.0 | 455.0 | 585.0 |
| Population per square mile | 730 | 950 | 1235 | 1655 | 2125 |

## WATER USAGE

Available data indicate that in the mid 1960's, about 230,000 people and several industries received approximately 25 mgd from the Newport News Department of Public Utilities. Projections of municipal and industrial water demands are presented in Table 108, and shown graphically on Figure 86.

About 30 percent of the Newport News filtration plant output is utilized by industrial and military facilities. For the purposes of making projections in this study, the 30 percent figure was maintained as a constant. While publicly-supplied industrial needs are expected to more than triple, self-supplied industrial requirements are expected to double over the next 50 years.

TABLE 108

WATER USAGE

NEWPORT NEWS UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 17.0 | 28.0 | 42.0 | 63.0 |
| Publicly-supplied industrial | 8.0 | 12.0 | 19.0 | 27.0 |
| TOTAL M & I | 25.0 | 40.0 | 61.0 | 90.0 |
| Publicly-supplied industrial | 8.0 | 12.0 | 19.0 | 27.0 |
| Self-supplied industrial | 20.0 | 23.0 | 33.0 | 44.0 |
| TOTAL INDUSTRIAL | 28.0 | 35.0 | 52.0 | 71.0 |
| Water Use (gcd) (Based on M & I) | 108.0 | 117.0 | 134.0 | 154.0 |

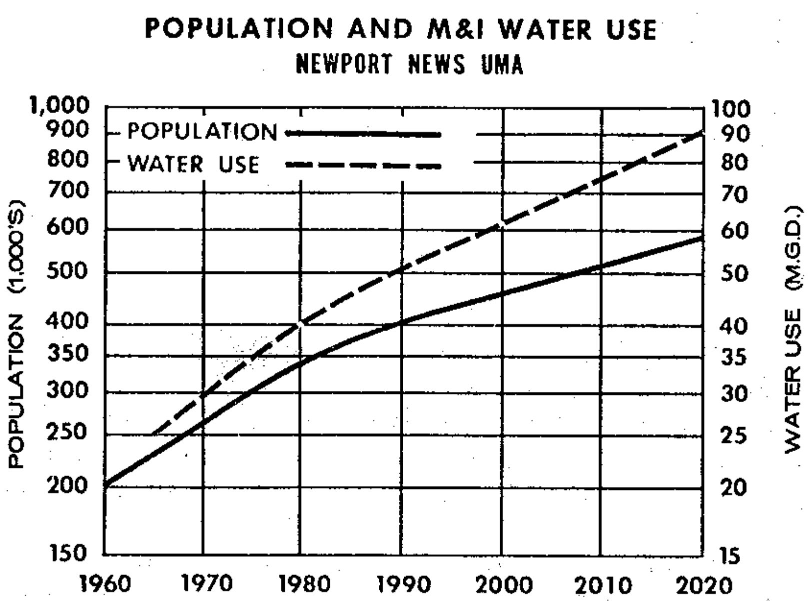



FIGURE 86

## KNOWN WATER SUPPLIES

### Summary

The Newport News Department of Public Utilities presently supplies water to almost all of the UMA. Water is obtained from a network of four reservoirs: Diascund Creek, Skiffes Creek, Harwoods Mill, and Lee Hall. The latter two reservoirs are maintained full for emergency reserve (5 mgd combined safe yield).

In addition to these sources of supply, an impoundment and pumping facilities on the Chickahominy River at Walker are used to augment the 5 billion gallons of storage provided by the four reservoirs. The total safe yield, excluding the emergency reserve, of the system is approximately 30 mgd, an amount which has been exceeded during periods of peak demand in recent years. Treatment and transmission capacities are reported to exceed slightly the aggregate safe yield of existing sources. Therefore, the water supply capability is rated at 30 mgd.

Present expansion of the Walker pumping station on the Chickahominy, new transmission mains, and a new 20 mgd treatment facility at Lee Hall, will increase the capacity of the Newport News system to 50 mgd. A portion of this expansion will be allocated to industry in Williamsburg and for domestic supply in James City County, areas outside of the expected UMA.

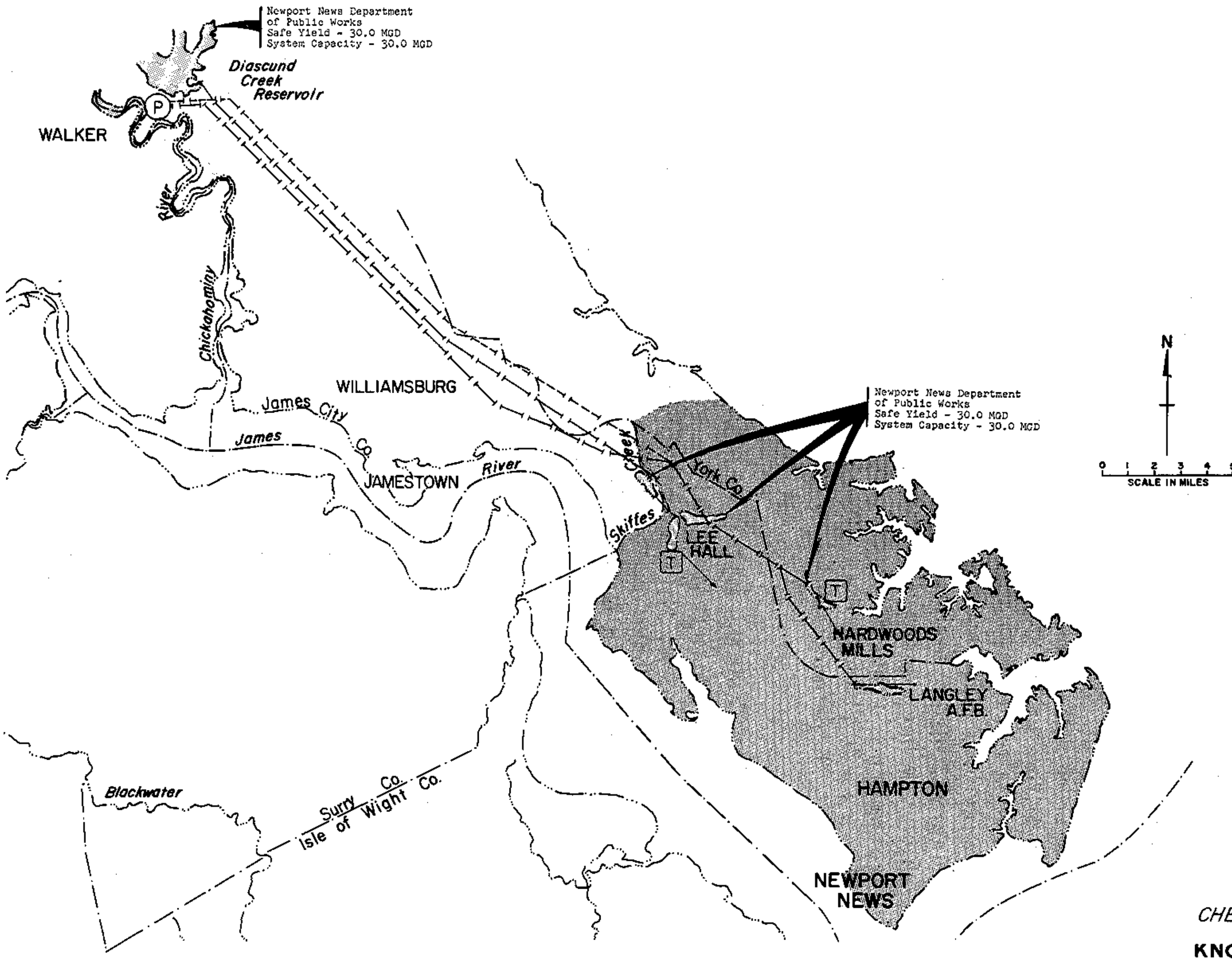
Data pertinent to the Newport News water supply system are presented in Table 109. The existing system, including facilities under construction, is represented schematically on Figure 87.

TABLE 109

KNOWN WATER SUPPLIES

NEWPORT NEWS UMA

| System | Mid 1960's Pop. Served | Mid 1960's Water Use (mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capacity (mgd) |
|---|---|---|---|---|---|---|---|---|
| Newport News Department of Public Utilities | 230,000 | 25.0 | Surface | Diascund Creek Skiffes Creek Lee Hall, and Hardwoods Mill Reservoirs | 30.0 | 36.0 | 40 | 30.0 |




**KNOWN WATER SUPPLIES**
**NEWPORT NEWS UMA**
**FIGURE 87**

Anderson-Nichols & Co. Inc.

Future Adequacy

The present capability of the Newport News system is rated at 30 mgd, the treatment capacity of plants at Lee Hall and Harwood's Mill. The system's capacity will increase to 50 mgd upon completion of intake, transmission, and treatment facilities. The projected UMA water demands presented in Table 110 indicate a deficit in water supply capability before the year 2000.

The actual deficits may occur sooner, and are largely dependent upon obligations to which the city commits itself in the very near future. Supply commitments to jurisdictions outside of the UMA are presently about 4 mgd, and are expected to increase to about 17 mgd by the year 2020. For this reason, the deficits including Williamsburg and James City County are shown in the footnote below Table 110.

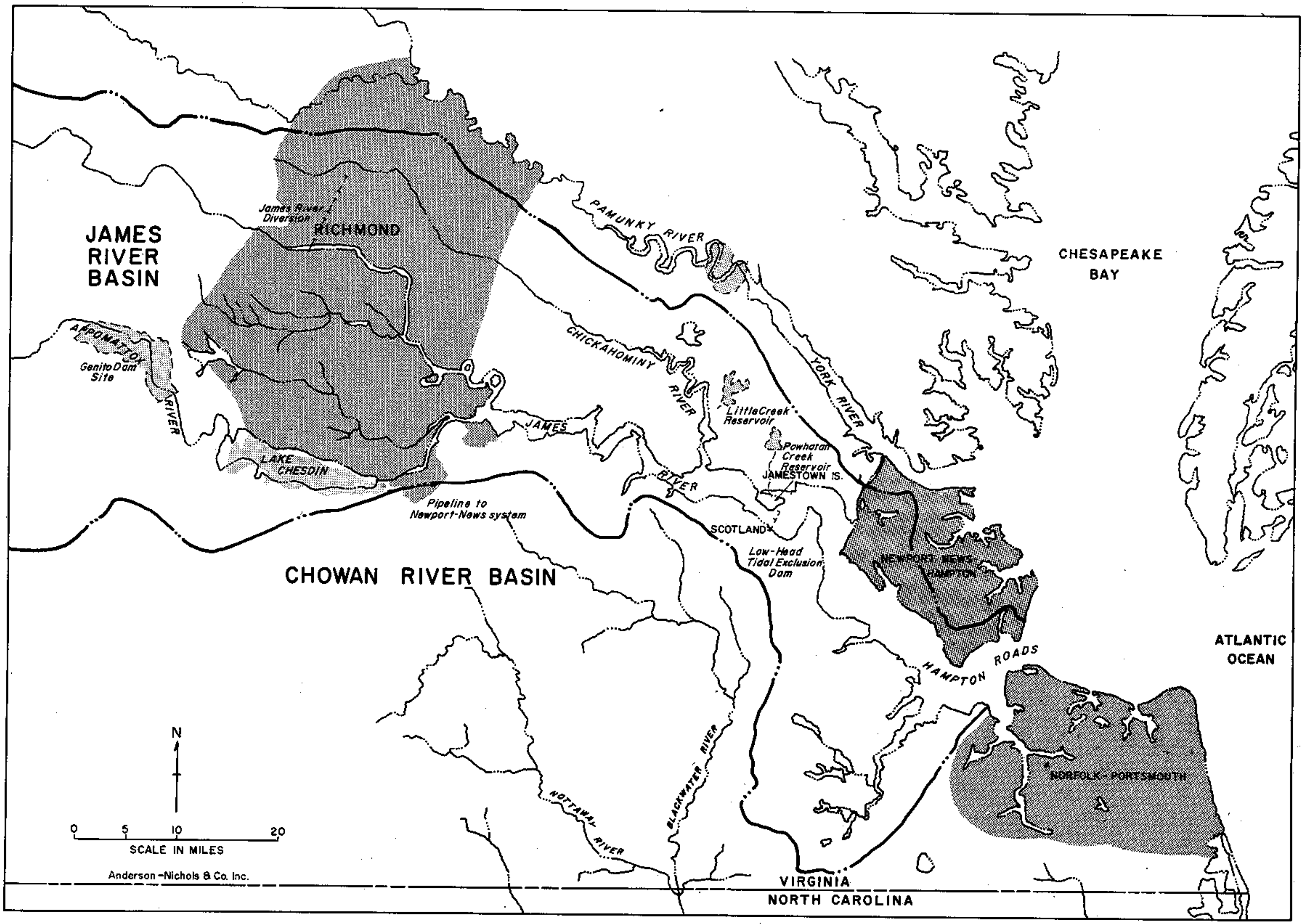
TABLE 110

ADEQUACY OF PRESENT WATER SUPPLY SYSTEM

NEWPORT NEWS UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 25 | 40 | 61 | 90 |
| Present Capability (mgd) | 30 | 50 | 50 | 50 |
| Deficit (mgd) 1/ | -- | -- | 11 | 40 |

1/ The deficits would be 20 mgd and 57 mgd for 2000 and 2020, respectively, if Williamsburg and James City County were included.




**POTENTIAL SOURCES OF SUPPLY**
**NEWPORT NEWS UMA**
**FIGURE 88**

## DESIRABILITY FOR REGIONALIZATION

The Newport News Department of Public Utilities is the water system that currently supplies the entire UMA. In the past, the department has demonstrated that it can provide water more efficiently and economically to the water-deficient urban area, than if each subdivision were to develop its own system. Expansion of the water service area to include Williamsburg and James City County is presently underway, and should prove economically beneficial both to purchasers and seller, since opportunities for individual system development of small reservoirs and wells has proven to be undesirable. The Newport News Department of Public Utilities should continue to monitor and improve its water supply system, and should be prepared to accommodate the indicated future needs of those areas through which its transmission mains pass.

## DEVELOPMENT ALTERNATIVES

Completion of pumping, transmission, and treatment facilities now under construction will increase the capacity of the Newport News water supply system to 50 mgd, rendering the system adequate until about 1987. Individuals responsible for water supply planning in the Newport News area will thus have time to evaluate the several water supply schemes that follow. Each has been investigated by consulting engineers, and state and local planners; they are shown on Figure 88. Although opportunities for the development of reservoirs within the peninsula do exist, they are not included in this discussion because they are scarce and relatively small. The reservoir sites could probably be used more efficiently in supplying water to the more remote areas in the northwestern section of the peninsula. Similarly, ground water development in the middle peninsula presents much the same picture as surface water sites. Several wells have been observed to yield about 0.1 mgd; which might best serve light industry and scattered housing development.

### Chickahominy Diversion to Little Creek Reservoir

The city of Newport News has indicated that the next phase in its water supply development plan will entail diversion of water from the Chickahominy River at Walker, to a proposed reservoir site on Little Creek. The project is at the "drawing board" stage, and would consist of increased pumping facilities on the Chickahominy, and constructing a dam of approximately 67 feet high on Little Creek. Although the reservoir has a very small drainage area and little potential as a natural runoff collection facility, it has a reported capacity of about 6.2 billion gallons, and could serve well as an off-stream storage facility for diversions.

At the time of construction of Little Creek reservoir, new transmission and treatment facilities will also be necessary. This project would increase the capacity of the Newport News system to about 65 mgd, enough to supply the projected needs of the service area, not including Williamsburg and James City County, through the year 2000.

Construction costs, including site and right-of-way acquisitions, treatment and pumping facilities, transmission mains, and reservoir would be approximately $14 million dollars.

Chickahominy Diversion to Powhatan Creek

This project would consist of pumping facilities on the Chickahominy and an impoundment on Powhatan Creek. (see Figure 88). The reservoir has little drainage area, but with a capacity of nearly 7 billion gallons, would prove to be an excellent site for off-stream storage. The project would be similar to the diversion to Little Creek.

The project would represent maximum desirable diversion of natural flow from the Chickahominy River, if diversion to Little Creek were already in effect, and would increase the yield of the system by about 25 mgd to 90 mgd, enough water to satisfy the expected needs of the Newport News Service area through the year 2010. Construction costs of the project would be about $15 million.

Pamunkey River

A low barrier dam on the Pamunkey River above West Point has been suggested by the consultant to the city of Newport News as a possible source of water for the peninsula. Drainage area, storage capacity, and safe yield of such a reservoir would be very large. The plan would call for the interbasin transfer of water via pumping and transmission mains to a stream feeding the existing Diascund Creek Reservoir. The transfer of water from the York River Basin could possibly raise objections from individuals with riparian rights to the water, and would undoubtedly have an effect on the York River ecosystem.

The distance from West Point to Diascund Creek is over 10 miles; transmission and barrier dam costs would seem to make this undertaking less desirable than the preceding alternatives. However, the dam would probably be one of the more economical additional sources of water beyond the year 2010.

James River Diversion to Chickahominy River

An alternative to the diversion of waters from the Pamunkey River is the diversion from the James River to the Chickahominy River. With increased flow in the Chickahominy River, facilities at Walker could be expanded to meet the projected needs of the Newport News area.

The most economically feasible diversion route appears to be from a point on the James River just west of Richmond, to a tributary of the Chickahominy about 9 miles north. Facilities would include a pumping station on the James River and 9 miles of transmission mains, the size of which would be contingent upon the amount of flow desired in the Chickahominy at Walker. An analysis done by the Bureau of Water Resources, State Water Control Board, Commonwealth of Virginia indicates that the actual cost of diverting water from the James to the Chickahominy would range from 3 to 6 cents per 1000 gallons, depending upon the quantity.

In view of the fact that the James River serves as the primary source of water for M & I usage in the Richmond UMA, it must be emphasized that no water should be diverted from the James River until the effect of two low-flow augmentation projects is evaluated under severe drought conditions. Gaithright (under construction) and Hipes Reservoirs (proposed) will reportedly double the low-flow at Richmond. If this proves to be the case, the diversion plan could be implemented with a minimum of conflict among the municipalities involved. Some opposition should be anticipated, however, if diversion of water is seriously considered from either the James to Chickahominy Rivers or the Pamunkey River (York River Basins) to Diascund Creek Reservoirs.

Pipeline from Lake Chesdin

The Appomattox River above the city of Petersburg was the subject of a water supply study in 1958 for the cities of Norfolk, Portsmouth, Petersburg, Colonial Heights, Newport News, and Chesterfield County. It was concluded that two impoundments on the river, at Sutherland and Genito, would provide an adequate quantity of high quality water at least through the year 2000. The proposal was rejected by Newport News, however, because of the extremely high costs of transmission facilities.

In 1968, the construction of Brasfield Dam at Sutherland was completed, along with a 22 mgd treatment plant. The initial customers of the Appomattox River Water Authority (A. R. W. A.) were Petersburg and Colonial Heights, with Chesterfield, Dinwiddie, and Prince George Counties to begin purchases upon the establishment of water systems or completion of proposed facilities. At present the Authority is providing an average of 12 mgd to its customers.

Lake Chesdin, the existing reservoir, has a safe yield of about 100 mgd available for water supply. This amount is expected to be enough to meet the needs of the A. R. W. A., as it is presently organized, through the year 2020. Allocation of water from the Appomattox River to the Norfolk UMA is also regarded as a desirable source of water for that area. If the demand ever dictated it, a second reservoir at Genito could be constructed, which could store 44 billion gallons, and could increase the safe yield of Appomattox River water supply development to over 400 mgd.

Use of the Appomattox River for water supply has several advantages: reasonably low costs of impoundment; minimum conflicts of interests; and good quality water. However, in view of the other alternatives available to the Newport News area, the advantages would probably be far outweighed by the high costs of transmission and pumping. Two alternative routes of transmission to Walker were pointed out in the original feasibility study. Construction costs on the order of $35 million could be expected for pipelines and pumping facilities for either route.

James River - Low Head Tidal Exclusion Dam

A dam across the James River between Jamestown Island and Scotland could provide a tremendous amount of yield - 675 mgd - for Tidewater Virginia. Advocates of the project have asserted that the dam would:

- Provide fresh water for industrial and municipal needs on both sides of the James River.
- Provide a dam which could be utilized as the basis of a highway, thus eliminating the ferry now in use in the area.
- Deepen the channel to Richmond and save on dredging, a necessity if the existing channel is deepened.
- Eliminate the necessity of further expansion of fresh water sources in the tidewater and Richmond areas.

However, high costs and an adverse ecological impact would probably outweigh the advantages. The dam would be over a mile in length and would cost nearly 300 million dollars. It would also flood a reported area of 50 square miles of bottom land presently above sea level. Considering the urban and industrial waste producing development above the proposed site, the quality of water obtained would probably be extremely poor, unless major treatment of upstream effluents were instituted. Further, the shellfish environment in the lower James below the dam would be disrupted by it, an important economic consideration for the area.

Desalting

Desalting is the all-inclusive term for the various processes used to purify salt or brackish water for purposes of municipal water supply. Because of the proximity of the Newport News UMA to the Chesapeake Bay and to the York and James River estuaries, the practice of desalting has been the subject of a great deal of interest to planners in the area.

The major drawbacks of desalting have been related to economics and waste disposal. However, in recent years, desalting technology has progressed greatly. An extensive and rapidly expanding spectrum of capabilities is now available, which can be adapted to many different situations, including the accomodation of both brackish and sea water; the adaptability of desalting to various sources of energy; and the available flexibility of design for optimum results under various size, price, and economic conditions.

As breakthroughs in technology are reached in the future, the costs of desalting will decrease. Eventually, a break-even point in costs may be reached, by which it will be more economical for the Newport News area to use salt or brackish water, at least as a supplementary source, rather than to seek fresh water from increasing distances. The present evaluation of desalting versus conventional fresh water development must favor the latter for at least the next 15 to 20 years. It seems desirable that development of additional capacity should be phased, if possible, to take advantage of desalting technology, but always with the capability to expand the fresh water development.

### Wastewater Reuse

Reuse of wastes as a possibility for water supply will merit consideration in the Newport News UMA within the time frame of this study. While actual engineering feasibility, public acceptance, and high costs are presently deterrents, continued research in water-short areas of the nation may lead to breakthroughs in one or all of these factors.

A more detailed discussion on desalting and wastewater reuse is the subject of Chapter 5, Volume I, Main Report.

## CONCLUSIONS

The Newport News water supply system, including facilities presently under construction, should be adequate to meet the needs of its expanding service area until 1987. The next step in the construction of water supply facilities in the Newport News plan will probably include a diversion from the Chickahominy River to an impoundment site on Little Creek. This addition to the Newport News system would insure the water supply through the year 2000.

Beyond 2000, the Newport News area should obtain water from one or more of the sources listed below. Although the projects are presented in order of apparent priority, based on present judgment, the decisions to use "James River Diversion to the Chickahominy River" in favor of the "Pamunkey River" is still an open question. Breakthrough in technology, public acceptance, and economics may favor "Desalting" and/or "Wastewater Reuse" in the future.

- Chickahominy Diversion to Powhatan Creek
- James River Diversion to the Chickahominy River
- Pamunkey River
- Pipeline from Lake Chesdin
- Desalting
- Wastewater Reuse
- James River - Low Head Tidal Exclusion Dam

# CHAPTER 27. NORFOLK

The Norfolk Urban Metropolitan Area is located on the southeastern coastal plain of Virginia, approximately 150 miles southeast of Washington, D. C. It contains the core cities of Norfolk and Portsmouth, and the northern urban portions of Chesapeake and Virginia Beach. By the year 2020, urbanization is expected to extend southward, 15 miles from the port of Hampton Roads; and the UMA is anticipated to encompass an area of about 400 square miles. The UMA is depicted on Figure 89.

In general, the area is flat, with elevations extending only 20 feet above sea level, and is characterized by numerous tributaries to the major bodies of water. The streams are mostly tidal estuaries, draining small basins of low relief.

The region is distinguished by a temperate climate. Because of its proximity to the Atlantic Ocean, and its latitude of approximately $36^{\circ}50'$, the UMA experiences moderate winters. Rainfall averages nearly 50 inches, while snowfall usually amounts to only 10 inches; annual runoff is approximately 10 inches. The average temperature is about $61^{\circ}F$, but January and July averages are about $43^{\circ}F$ and $80^{\circ}F$, respectively. Winds generally prevail from the southeast.

Virtually every form of transportation is available in the Norfolk area. An excellent highway network of both Interstate and U.S. routes provides access to metropolitan areas along the eastern seaboard. Rail service to all major eastern citites is provided by the Chesapeake and Ohio Railway; Norfolk, Franklin, and Danville Railway; Norfolk Southern Railway; and the Penn Central Railroad. Air service is accomodated by the Norfolk Regional Airport, which offers service on major national airlines and connections to international airlines. Other smaller airports, including a heliport in Norfolk, are located in the southern Hampton Roads area.

The port of Hampton Roads, comprised of the Norfolk and Newport News UMA's, claims importance as one of the more highly industrialized and heavily populated ports on the Atlantic coast. Located at the mouth of the James River, it is a major shipbuilding center and a leading southern seaport. Hampton Roads has one of the foremost and largest natural harbors in the world.

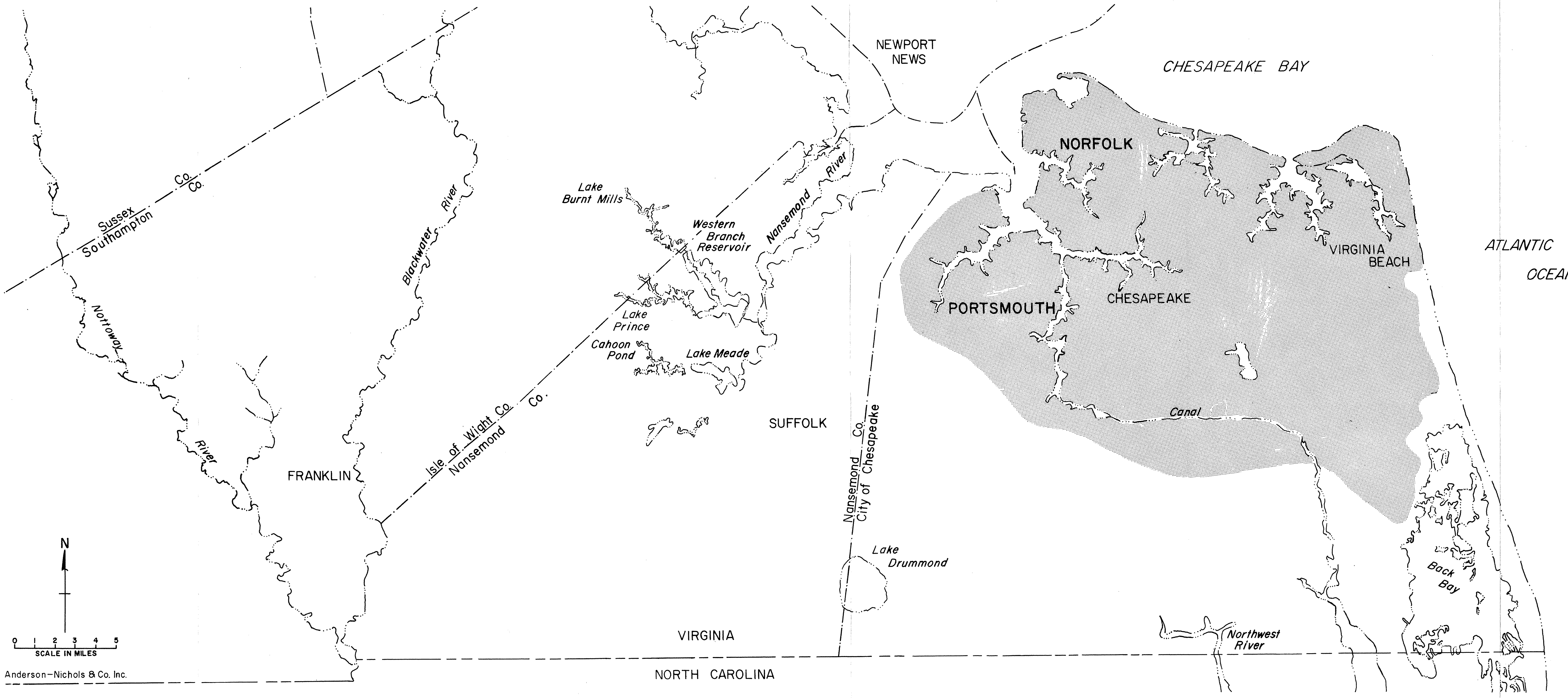
The United States Navy has several major installations in the area, including the Norfolk Navy Base, the Norfolk Navy Yard and the Portsmouth Naval Hospital. Norfolk-Portsmouth is one of the largest naval bases in the country, and the economic stability of the UMA is very dependent upon the military establishment. As a result of the military, population growth is variable, and may fluctuate greatly within short periods of time. In 1960, military employment alone (not including employment of military families and military-related personnel) accounted for 23 percent of the total employment of the UMA.

Norfolk is an important ship outfitting and repair center, and a major commercial port, as well as the headquarters of the Atlantic Fleet, the U.S. Army's Continental Command, and a major military embarkation point. Norfolk is a deep-water coal terminal, handling large volumes of Appalachian coal that are transshipped from the inland mine regions; hence, it is one of the largest export ports in the country. Norfolk's economic base also includes, to a small extent, tourism, tobacco, coal and petroleum shipping, automobile, rail and ship repair, breweries, food processing, and mattress manufacture.

The importance of the U.S. Navy to the economy of the Norfolk area requires emphasis. The Navy is the cheif source of employment and reason for fluctuation in population. The great harbor of Hampton Roads will always remain important for general commerce; but the enormous influence of the U.S. Navy poses a constant threat to the economic stability of the area. Any major reduction in Naval personnel or shipping could have disastrous consequences for Norfolk and the surrounding region. For this reason, the "single-industry" economic base of Norfolk must be recognized as tenuous and variable, subject to changes in the policy of the Federal government toward the military.

## POPULATION

The Norfolk UMA has experienced rapid development, particularly since 1940. It is believed that the area's present population of 668,300 will nearly double by the year 2020. Table 111 gives the projected populations and densities for the UMA.




**NORFOLK UMA**

**FIGURE 89**

TABLE 111

POPULATION DATA

NORFOLK UMA

| | 1960 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|
| Population (in thousands) | 520.0 | 668.3 | 769.0 | 983.0 | 1,230.0 |
| Population per square mile | 1,300 | 1,670 | 1,925 | 2,460 | 3,075 |

## WATER USAGE

In determining the population and water use projections for the Norfolk UMA, two assumptions were made:

- Approximately 20 percent of the total area requirements have in the past been attributed to military installations and light industrial water users. This trend is expected to continue in the future.

- Large water-using industries are generally of the types that can satisfy their cooling needs with the nearly unlimited supply of brackish water present in tidal estuaries throughout the area. It is assumed that these industries will continue to supply themselves with water.

Projections of M & I water demands are presented in Table 112, while Figure 90 depicts the population and water use predictions graphically.

## KNOWN WATER SUPPLIES

### Summary

Municipal water is supplied to the cities of Norfolk, Portsmouth, Chesapeake and Virginia Beach by the facilities of Norfolk and Portsmouth. The area may be considered regionalized to a degree, in that Norfolk supplies parts of Chesapeake and Virginia Beach, and Portsmouth supplies part of Chesapeake, the city of Suffolk, and portions of Nasemond County.

Water is obtained from a complex of several small- to medium-sized reservoirs, located approximately 25 miles west of Norfolk near Suffolk. Water from these reservoirs is augmented with water pumped

TABLE 112

WATER USAGE

NORFOLK UMA

| | Mid 1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Water Demands (mgd) | | | | |
| Domestic | 52.0 | 78.8 | 115.2 | 165.2 |
| Publicly-supplied industrial | 13.0 | 19.7 | 28.8 | 41.3 |
| TOTAL M & I | 65.0 | 98.5 | 144.0 | 206.5 |
| Publicly-supplied industrial | 13.0 | 19.7 | 28.8 | 41.3 |
| Self-supplied industrial | 19.0 | 26.0 | 40.0 | 55.0 |
| TOTAL INDUSTRIAL | 32.0 | 45.7 | 68.8 | 96.3 |
| Water Use (gcd) (Based on M & I) | 113.0 | 128.0 | 146.0 | 168.0 |

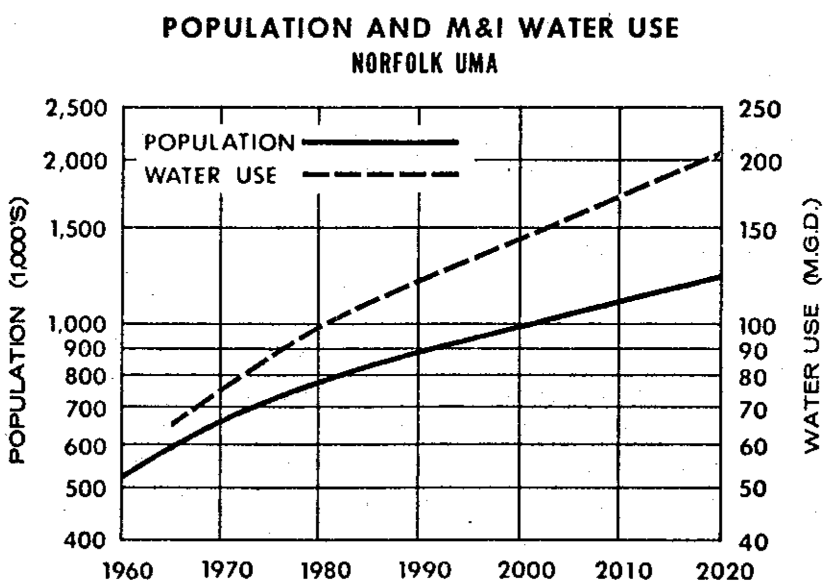
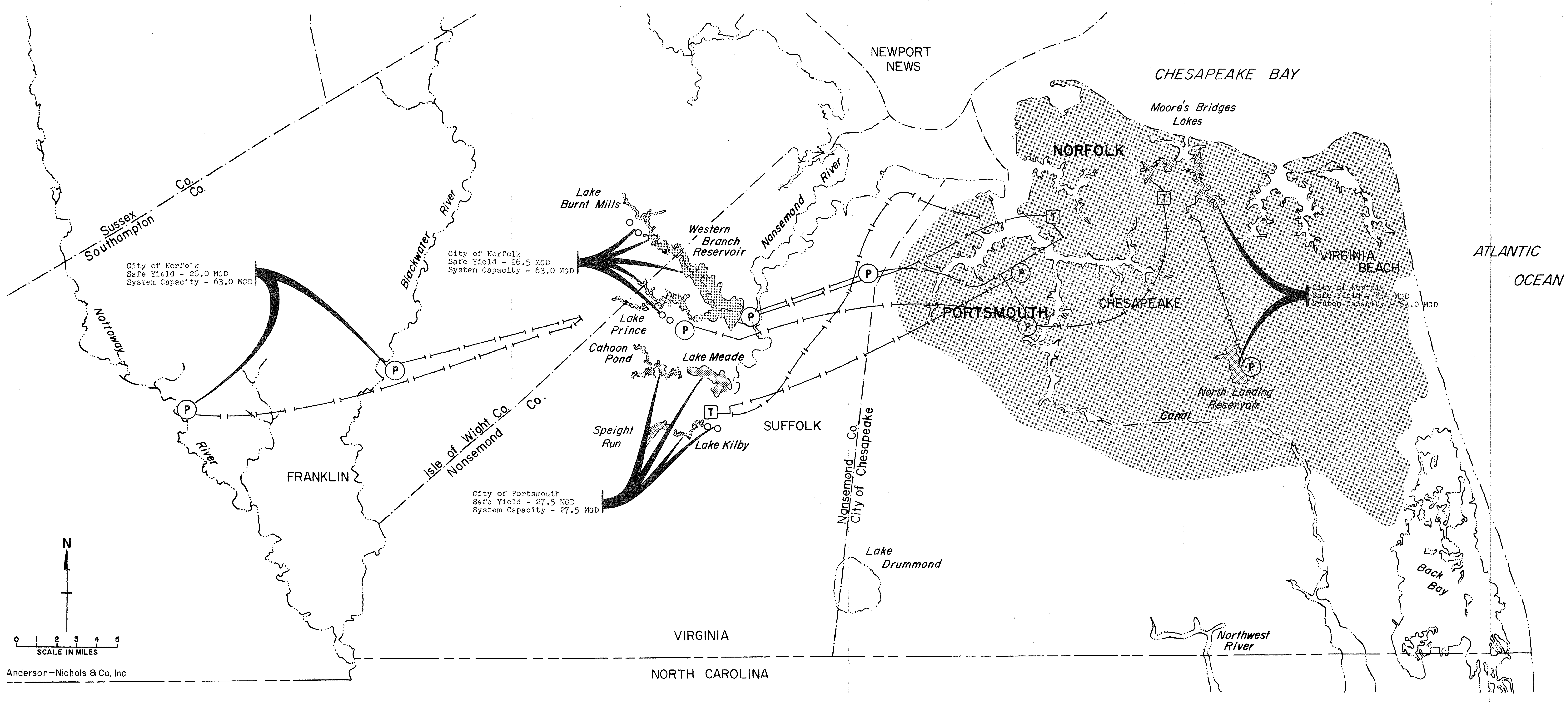



FIGURE 90




**KNOWN WATER SUPPLIES NORFOLK UMA**

**FIGURE 91**

from the Nottaway and Blackwater Rivers in the Chowan River Basin, and additional supply is obtained from six municipal wells. The estimated combined safe yield of all sources developed for the Norfolk area is over 100 mgd. The combined peak capacity of the treatment plants is estimated to be 130 mgd, while transmission mains are reportedly capable of carrying 135 mgd. The total capability of the Norfolk and Portsmouth systems, however, is rated at 90.5 mgd, the nominal treatment plant capacity.

The Northwest River, flowing through the southern portion of the city of Chesapeake, is being considered seriously as a source of supply for that city. Chesapeake presently obtains water at premium rates from both Norfolk and Portsmouth, but is making an effort to develop its own source of water. The city feels that it can provide water for municipal and industrial purposes at lower rates than the present situation permits; thus, it is encouraging its own development. Although Chesapeake's request to impound Northwest River waters has been denied by the Corps of Engineers, the city plans to pump 6 mgd directly from the river. The project is considered somewhat undesirable, because a problem may arise from the fact that the river traverses more than one state. Furthermore, the Northwest is also being considered, but has not as yet been recommended, for classification by the Virginia Commission of Outdoor Recreation as a "scenic" river.

The existing water supply systems are depicted on Figure 91, and data pertinent to them are presented in Table 113.

TABLE 113

KNOWN WATER SUPPLIES

NORFOLK UMA

| System | Mid-1960's Pop. Served | Mid-1960's Water Use(mgd) | Type | Major Source Name | Safe Yield (mgd) | Treat. Capacity (mgd) | Trans. Capacity (mgd) | System Capac. (mgd) |
|---|---|---|---|---|---|---|---|---|
| City of Norfolk | 410,000 | 50.0 | Surface<br>Surface<br>Ground | 5 Reservoirs<br>2 Reservoirs<br>4 Wells | 34.9<br>26.0<br>15.0 | 63.0 | N/A | 63.0 |
| City of Portsmouth | 165,000 | 15.0 | Surface<br>Ground | 4 Reservoirs<br>2 Wells | 22.0<br>5.5 | 32.0 | N/A | 27.5 |
| City of Norfolk | 410,000 | 50.0 | Surface<br>Surface<br>Ground Water Wells - 4 | 5 Reservoirs<br>2 Direct Pumping | 34.9<br>26.0<br>15.0 | 63.0 | N/A | 63.0 |
| City of Portsmouth | 165,000 | 15.0 | Surface<br>Ground Water Wells - 2 | 4 Reservoirs | 22.0<br>5.5 | 32.0 | N/A | 27.5 |

## Future Adequacy

The combined total capacity of the Norfolk and Portsmouth water systems is rated at 90.5 mgd, the capacity of the three treatment plants. When compared with the projected water demands in Table 114, it becomes apparent that almost immediate development of water supply is necessary; by the year 2020, about 120 mgd additional capacity must be provided.

TABLE 114

ADEQUACY OF PRESENT WATER SUPPLY SYSTEMS

NORFOLK UMA

| | Mid-1960's | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Public Water Demand (mgd) | 65.0 | 98.5 | 144.0 | 206.5 |
| Present Capability (mgd) | 90.5 | 90.5 | 90.5 | 90.5 |
| Deficit (mgd) | -- | 8.0 | 53.5 | 116.0 |

## DESIRABILITY FOR REGIONALIZATION

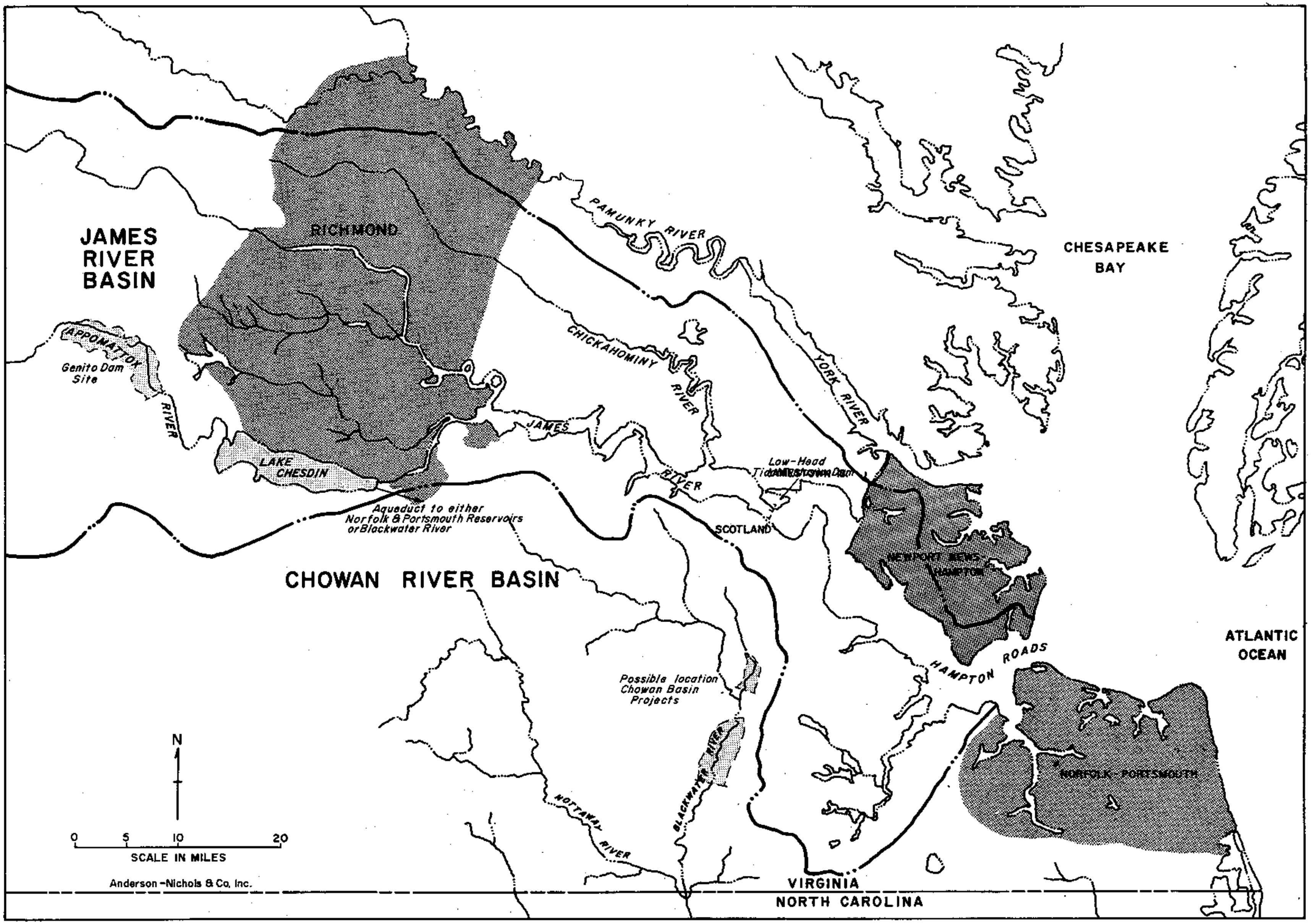
Demographic and industrial growth will dictate the need to develop additional sources of water supply for the municipalities in the Norfolk area. The development of local sources by the cities of Norfolk and Portsmouth has been accomplished on a piecemeal basis, so that at present, almost every suitably sized source of water in close proximity to the UMA is being utilized. Consequently, water suppliers in the area are confronted with the problem of importing water from increasing distances. Regionalization and its economic and technical advantages in the development, transmission, and treatment of water supply are recognized by the municipalities concrened; but implementation is only in the early planning stages.

## DEVELOPMENT ALTERNATIVES

Consultants to the various political subdivisions in the Norfolk area have made several water supply studies, with the result that numerous schemes and sources for supply have been suggested. The locations of the suggested projects are shown on Figure 92.

### James River - Low Head Tidal Exclusion Dam

A dam across the James River between Jamestown Island and Scotland could provide a tremendous amount of yield - 675 mgd - for




**POTENTIAL SOURCES OF SUPPLY**
**NORFOLK UMA**
**FIGURE 92**

Tidewater,Virginia. Advocates of the project have asserted that the dam would:

- Provide fresh water for industrial and municipal needs on both sides of the James River.

- Provide a dam which could be utilized as the basis of a highway, thus eliminating the ferry now in use in the area.

- Deepen the channel to Richmond and save on dredging, a necessity if the existing channel is deepened.

- Eliminate the necessity of further expansion of fresh water sources in the Tidewater and Richmond areas.

However, high costs and an adverse ecological impace would probably outweigh the advantages. The dam would be over a mile in length and would cost nearly 300 million dollars. The dam would flood a reported area of 50 square miles of bottom land presently above sea level. Considering the urban and industrial waste producing development above the proposed site, the quality of water obtained would probably be extremely poor, unless major treatment of effluents were instituted. Further, the shellfish environment in the lower Hames below the dam would be disrupted by it.

Chowan River Basin

The Chowan River Basin is a fairly flat, swampy, and undeveloped 5,000 square-mile watershed, located west of the Norfolk UMA in southeastern Virginia and northeastern North Carolina. It has been investigated by consultants as a possible source of water supply for various political subdivisions throughout Tidewater, Virginia.

Several impoundment sites on tributaries to the Chowan River have been considered; the most feasible appear to lie on the Blackwater and Nottaway Rivers and Seacock Creek. The city of Norfolk is presently planning to increase supply capability with impoundments on the Blackwater, whose reported yields range from 50 to 250 mgd. The amount of flow to be released downstream to North Carolina would determine the total yield developed and the amount that could be allocated for water supply.

In the past, Norfolk has pumped at an average rate of 26 mgd (and at a maximum of 48 mgd) directly from its facilities on the

Blackwater and Nottaway Rivers, essentially eliminating any downstream flow during dry summer months. Apparently because of the relatively undeveloped nature of the Chowan Basin in Virginia and North Carolina, only modest opposition to this practice has been voiced by either state thus far. However, it should not be assumed that the present situation will be allowed to continue: to avoid future interstate conflicts, minimum downstream requirements should be agreed upon by Virginia and North Carolina.

In similar circumstances in other states within the NEWS Study area, agencies have recommended minimum downstream releases of about 0.2 cubic feet per second per square mile of drainage area. This would release a flow of approximately 130 cfs (87 mgd) downstream from any impoundment. Under these conditions, a safe yield of 207 mgd (120 mgd for Norfolk UMA, plus 87 mgd for downstream requirements) would have to be devised in the development of impoundments; storage requirements are estimated at approximately 50 billion gallons. It appears doubtful that such a large amount of storage could be provided in the Blackwater River watershed without an unreasonable amount of structural relocation. The possibility also exists that the proposal of <u>any</u> reservoir on the Blackwater River may be rejected, in view of the fact that the Blackwater is under consideration for classification as a "scenic" river.

An alternative solution lies in an impoundment, with considerably less storage and augmentation, by diversion from either the James or Appomattox Rivers to the headwaters of the Blackwater River. While it is an engineering certainty that adequate quantities could be diverted to the Blackwater headwaters, the scheme might possibly prove to be economically impractical, because the amount to be diverted has never been determined. A large amount of water might be expected to be lost to evaporation, and to ground water through percolation.

There are several major advantages of impoundment facilities on Chowan River Basin waters: the reservoirs would seemingly have a positive effect on the lower Chowan waters as a flood regulatory structure; facilities in the Basin could be planned and constructed with a minimum amount of conflict of interest, owing to the undeveloped nature of the area; present transmission mains to the Norfolk UMA would serve in the most economical development of any large sources of water available; and phased reservoir development could be implemented fairly easily.

Appomattox River

The Appomattox River above the city of Petersburg was the subject of a water supply study in 1958 for the cities of Norfolk, Portsmouth, Petersburg, Newport News, and Colonial Heights, and Chesterfield County. It was concluded that two impoundments, at Sutherland and Genito, would provide an adequate quantity of high wuality water at least through the year 2000. The proposal was rejected by Norfolk and Portsmouth, however, because of the extremely high costs of transmission facilities.

In 1968, the construction of Brasfield Dam at Sutherland was completed, along with a 22 mgd treatment plant. The initial customers of the Appomattox River Water Authority (A. R. W. A. ) were Petersburg and Colonial Heights, with Chesterfield, Dinwiddie, and Prince George Counties to begin water purchases upon the establishment of water systems or completion of proposed facilities. At present the Authority is providing an average of 12 mgd to its customers.

Lake Chesdin, the existing reservoir, has a drainage area of 1,335 square miles and a storage capacity of 11.5 billion gallons. Its total safe yield is approxima tely 165 mgd, while the amount available for water supply has been reported as 100 mgd. Since water supply, sewage dilution, and power requirements downstream on the Appomattox are considerably less than 65 mgd, the amount of 100 mgd available from Lake Chesdin is sufficient at least for the present. The possibility that the Appomattox River between Lake Chesdin and Petersburg may be classified as "scenic", however, may dictate greater minimum releases in the future.

In view of projected water demands for the A. R. W. A. service area, and the needs in the Norfolk vicinity that exceed the present capabilities, utilization of Lake Chesdin as a supplementary source of water for Norfolk would probably be feasible for nearly 30 years. (See Chapter 25. )

A second reservoir at Genito could be constructed, at a time to be determined by the demand. Genito Reservoir, situated west of Route 604, would have a drainage area of 715 miles. With a base elevation of 192 feet above sea level, the dam could be constructed to an elevation of 240 feet, and store approximately 44 billion gallons. This would increase the safe yield of the Appomattox River water supply development to over 400 mgd.

The area to be flooded by the Genito project is presently occupied by scattered farms and timber operations. Railroad relocation is not involved and future highway development would be only slightly affected. Thus, the costs for acquiring the necessary real estate for the second impoundment should be quite reasonable.

Data pertinent to both the existing impoundment at Brasfield Dam and the potential site at Genito are presented in Table 115.

TABLE 115

APPOMATTOX RIVER IMPOUNDMENT STATISTICS

| Name and Height of Possible Dam | Drainage Area (sq. mi.) | Storage (bg) | Base Elevation (ft. above msl) | Safe 1/ Yield (mgd) |
|---|---|---|---|---|
| Lake Chesdin (160 ft. msl) | 1,335 | 11.5 | 120 | 165 |
| Genito (213 ft. msl) | 715 | 5.4 | 192 | 88 |
| Genito (228 ft. msl) | 715 | 21.0 | 192 | 175 |
| Genito (240 ft. msl) | 715 | 44.3 | 192 | 260 |
| Genito (250 ft. msl) | 715 | 75.0 | 192 | 285 |

1/ Calculated by the methodology given in Chapter 4, Volume I; disregarding downstream requirements.

It is quite apparent from the preceding table that a combination of two developments on the Appomattox River could provide an adequate amount of water for both the A. R. W. A. and Norfolk service areas, providing that legalities could be arranged.

Transmission to the Norfolk UMA could be accomplished either by a closed aqueduct from Lake Chesdin to Norfolk and Portsmouth raw water lakes, or by diversion from Lake Chesdin to the headwaters of the Blackwater River, utilizing the existing facilities of the city of Norfolk.

The aqueduct, approximately 62 miles in length and 84 inches in diameter, could follow the right-of-way of Route 460, the most economical route. It could also be tapped as a source of raw water for developments between Petersburg and Suffolk. Cost of construction is estimated at $60 million.

The alternative delivery scheme would be considerably less expensive; however, losses of up to 50 percent, owing to evaporation and percolation to ground water, would probably necessitate the diversion of a far greater quantity of water, something which must be considered when planning for reservoir development. Be diverting out of the James River Basin, an additional amount of water could be lost to riparian users in the Blackwater River watershed. Some opposition should be anticipated, however, if diversion of water is seriously considered from the Appomattox River to the present facilities on the Chowan River for the Norfolk UMA.

Ground Water

Ground water in the Coastal Plain of Virginia is obtained from unconsolidated sands and clays of the Cretaceous age. Ground water occurs under both artesian and water table conditions.

Yields from existing wells in the Norfolk area vary, from a few gallons per minute in shallow, small-diameter domestic wells, to over a million gallons per day from large-diameter wells drilled several hundred feet deep, which have been developed for municipal and industrial purposes. Existing deep wells are located primarily in a narrow band between Portsmouth and Virginia Beach.

The coastal aquifers in southeastern Virginia are estimated to be nearly 2,500 feet thick; however, below a depth of 1,000 feet, the concentration of dissolved solids is considered too high for human consumption. Although the potential amount of water than can be withdrawn from aquifers underlying the Norfolk UMA is a function of storage and rate of replenishment, the quantity of acceptable ground water is limited by the presence of a saline encroachment interface, roughly bisecting the area in a north-south direction. Preliminary investigations indicate that the total amount of acceptable quality ground water available in the Norfolk UMA should approximate 50 mgd.

Future development of ground water as a supply source could offer three options:

- Wells could play a secondary or supplementary water supply role as sources for rural and industrial needs. In this case, the amount of available ground water would be approximately 50 mgd. A ground water management program would be necessary to insure proper utilization of resources.

- Control of the natural salt water interface by means of pumping troughs, pressure ridges, or impermeable subsurface barriers is very costly, and in experimental stages at present. The area's ground water potential, however, could be maximized to nearly 150 mgd.

- Recirculation of treated sewage effluent (wastewater reuse) to ground water, either by means of recharge wells, settling basins, or overland flows, would supplement the area's natural replenishment rate.

Desalting

Desalting is the all-inclusive term for the various processes used to purify sea water, so that it may be used for water supply.

Because of the Norfolk area's location near the Atlantic Ocean and the James River estuary, the practice of desalting has been the subject of various engineering and economic investigations. In the past, its major drawbacks have been related to economics and waste disposal. In recent years, however, desalting technology has progressed greatly. An extensive and rapidly expanding spectrum of capabilities is now available, which can be adapted to a great many different situations, including the accomodation of both brackish and sea water; the adaptability of desalting to various sources of energy; and the available flexibility of design for optimum results under various size, price, and economic conditions.

As breakthroughs in technology are reached in the future, the costs of desalting will decrease. Eventually, a break-even point in costs may be reached, by which it will be more economical for the Norfolk area to use salt or brackish water as a primary source, rather than to seek fresh water from increasing distances. The present evaluation of desalting versus conventional fresh water development must favor the latter for at least 15 to 20 years. It seems desirable that development of additional capacity should be phased, if possible, to take advantage of desalting technology, but always with the capability to expand the fresh water development.

A more detailed discussion on wastewater reuse and desalting is the subject of Chapter 5, Volume I, Main Report.

## CONCLUSIONS

Public water demands in the Norfolk UMA are expected to increase from 65 mgd in the mid-1960's to 99 mgd in 1980, and to 207 mgd by the year 2020. This represents a particularly acute problem, since the existing water supply systems in the UMA have a combined capability of only 90.5 mgd, and the potential solutions available to the area are not without drawbacks.

Total regionalization for the UMA, including planning and facilities development, appears both feasible and necessary, in light of the expected growth for the area, and the available source development opportunities.

Because of the possible political considerations, further development in the Chowan River Basin seems undesirable. Desalting has good possibilities for the long range future, but apparently not for problems arising in the period up to 1980.

The Appomattox River seems to offer the alternative that is most desirable and free of constraints, but its development would be rather expensive. The situation will require a major policy decision among local, State and Federal agencies. The choice of source development seems to be of paramount importance to the immediate future of the four cities in the Norfolk UMA.